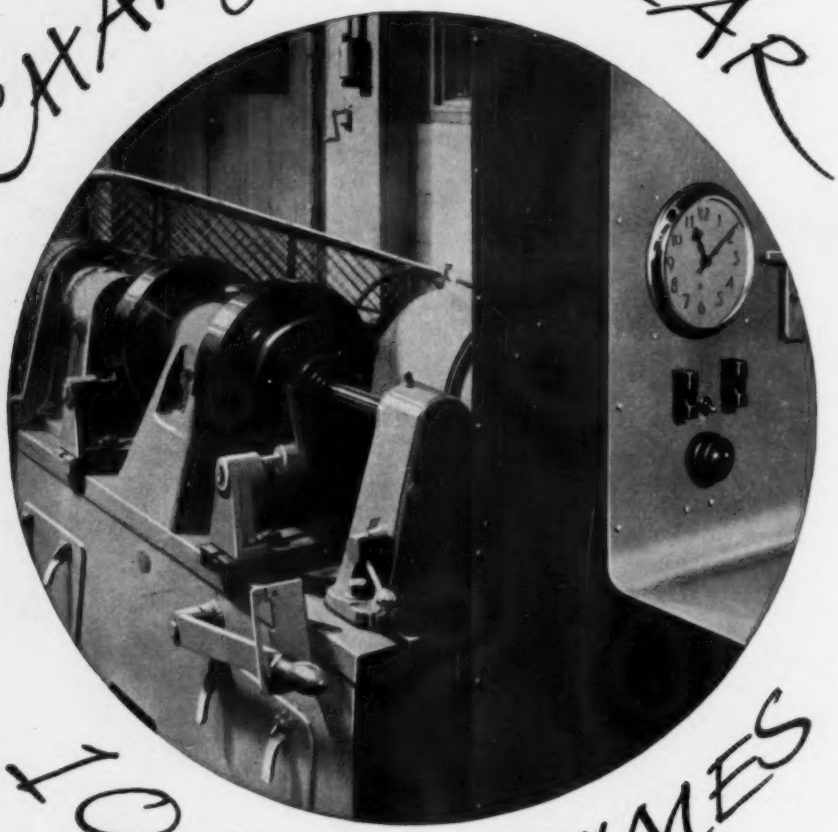
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 48 No. 5 MAY 1958 PRICE: 3s. 6d

Rod End Bearing
Single Row Self Aligning with Shields
Single Row Pulley Bearing
Double Row Pulley Bearing with Housing and Shield
Ball Bearing Pulley
Double Row Pulley Bearing
Single Row Pulley Bearing with Housing and Shield
Single Row Self Aligning with Shields
Torque Tube Type
Double Row Self Aligning
Single Row with Shields
Shrouded Ball Bearing Pulley
BEARINGS FOR LIGHT DUTIES AND CONTROLS
RANSOME
Ransome & Marles Bearing Co Ltd produce a comprehensive range of ball and roller bearings to suit every speed, load and application
BALL & ROLLER R&M BEARINGS
MARLES BEARING CO. LTD., NEWARK-ON-TRENT, ENGLAND

CHANGING GEAR



10,000 TIMES

In the B.B.A. Research and Development Laboratories this machine tests Mintex clutch liners. In a routine test, two clutches on a common shaft are engaged and disengaged automatically every twelve seconds no less than ten thousand times. During this time the clutch plate accelerates up to 1,200 r.p.m.

Tests such as these are everyday routine in the B.B.A. laboratories and are carried out on both production samples and on new and experimental liners. They form part of the continual programme of research and development on which the Mintex reputation is securely based.

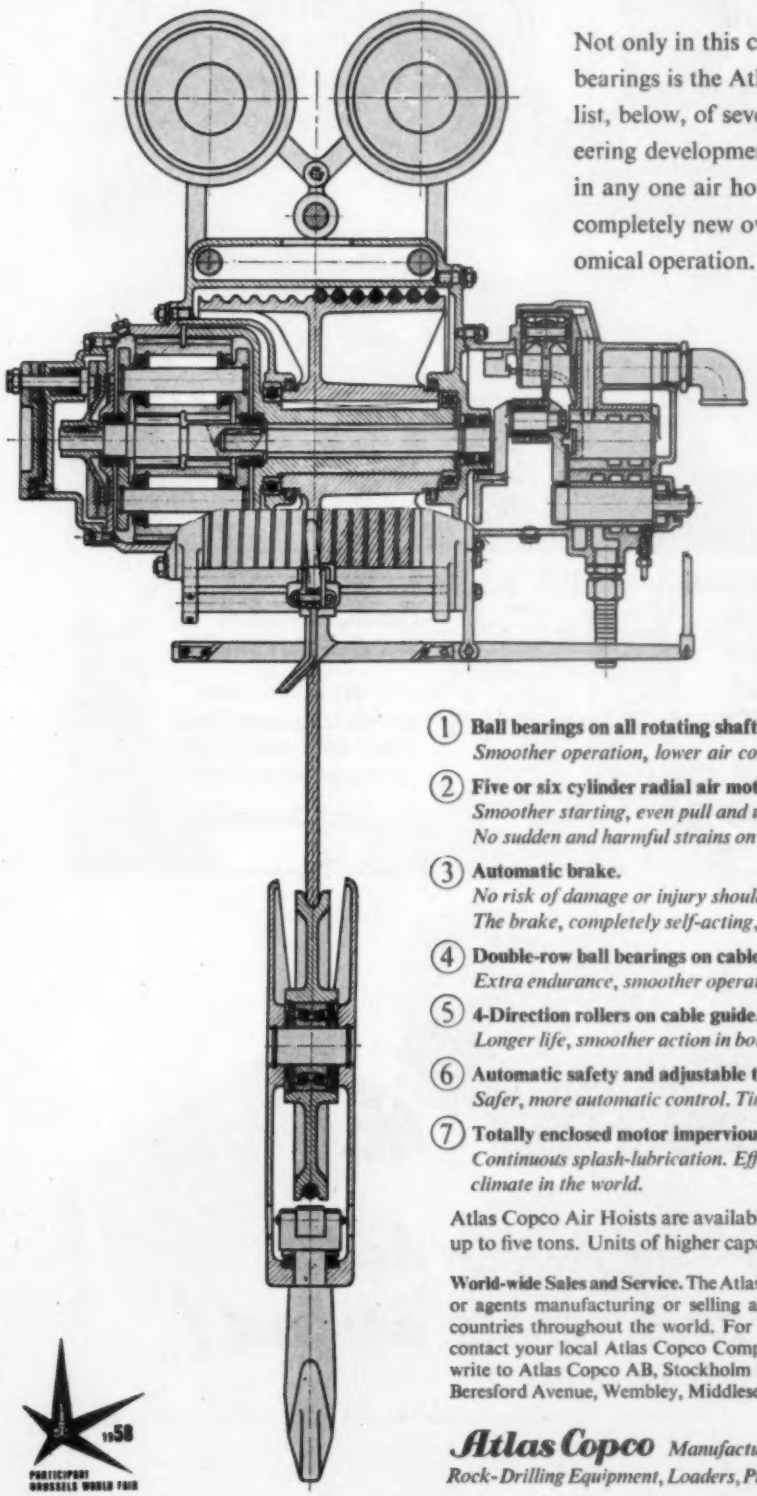
you can rely on

MINTEX

Mintex Brake and Clutch Liners are manufactured by British Belting & Asbestos Limited, Cleckheaton, Yorkshire, and are available from MINTEX Service Depots and Distributors throughout the country.

Only Atlas Copco Air Hoists

have ball bearings on all rotating shafts—roller bearings for connecting rods



Not only in this complete application of ball and roller bearings is the Atlas Copco Air Hoist unique. Read the list, below, of seven major features. These tested engineering developments have never before been combined in any one air hoist. Each plays its part in achieving a completely new overall standard of efficiency and economical operation.

① **Ball bearings on all rotating shafts and roller bearings for connecting rods.**
Smoother operation, lower air consumption, longer service life.

② **Five or six cylinder radial air motor.**
Smoother starting, even pull and ultra-sensitive control.
No sudden and harmful strains on goods handled.

③ **Automatic brake.**
No risk of damage or injury should air supply be interrupted.
The brake, completely self-acting, is only OFF when the air pressure is ON.

④ **Double-row ball bearings on cable sheave.**
Extra endurance, smoother operation at this critical point.

⑤ **4-Direction rollers on cable guide.**
Longer life, smoother action in both directions.

⑥ **Automatic safety and adjustable top and bottom stops.**
Safer, more automatic control. Time saved on repetitive jobs.

⑦ **Totally enclosed motor impervious to dust.**
Continuous splash-lubrication. Efficient, trouble-free operation ensured in any climate in the world.

Atlas Copco Air Hoists are available in a standard range covering capacities up to five tons. Units of higher capacities can be supplied to special order.

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DESOUTTER ARE GETTING RID OF HALF THEIR PEOPLE pass it on !
DESOUTTER AREN'T HALF THE PEOPLE THEY USED TO BE pass it on !
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Desoutter send over half their tools abroad!

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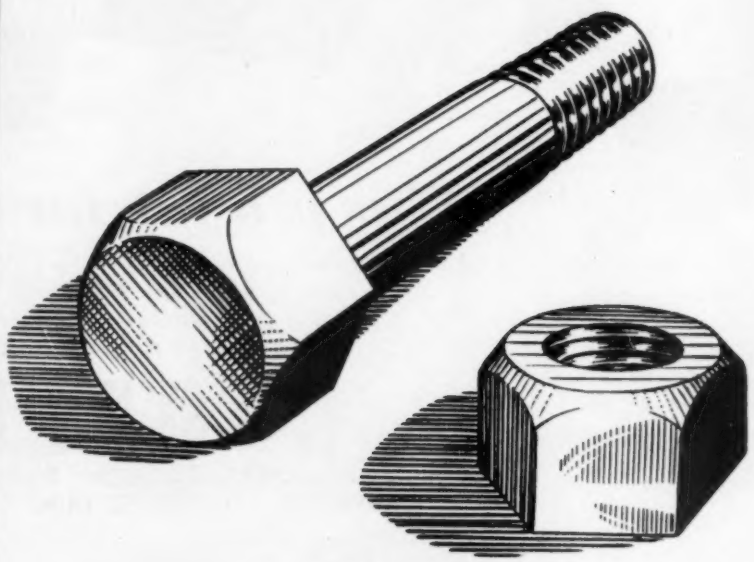
QUALITY STEELS FOR NUTS & BOLTS



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high tensile steel bars

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The
BORG
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REG'D. TRADE MARK
7¼" clutch
BORG & BECK COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

Showing the internal fluid way.
The brake shown is the M-type, 5½ sq. in. lining, ⅜" thick.
The H-type has lining 7¼ sq. in. area, ½" thick.

PATENTS PENDING

FEATURES OF THE LOCKHEED HYDRAULIC DISC BRAKE

THE INTERNAL FLUID WAY

Among the many safety features of the Lockheed disc brake is the internal fluid way between the cylinders, eliminating the usual bridge pipe and simplifying installation. The fluid way has a single seal.

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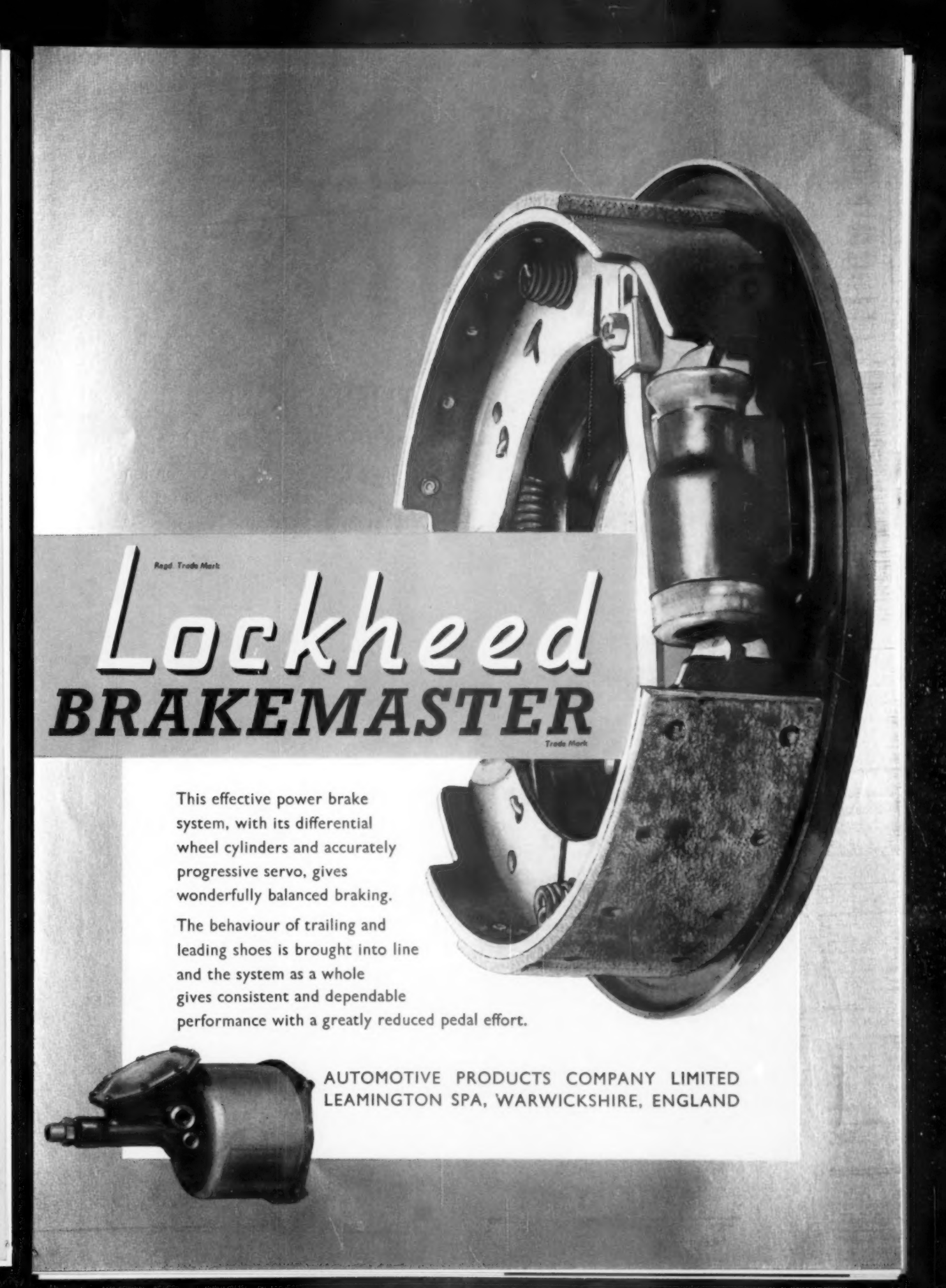
Safety...by **LOCKHEED**

Registered Trade Mark: LOCKHEED


Regd. Trade Mark
Lockheed
BRAKEMASTER
Trade Mark
This effective power brake system, with its differential wheel cylinders and accurately progressive servo, gives wonderfully balanced braking.
The behaviour of trailing and leading shoes is brought into line and the system as a whole gives consistent and dependable performance with a greatly reduced pedal effort.
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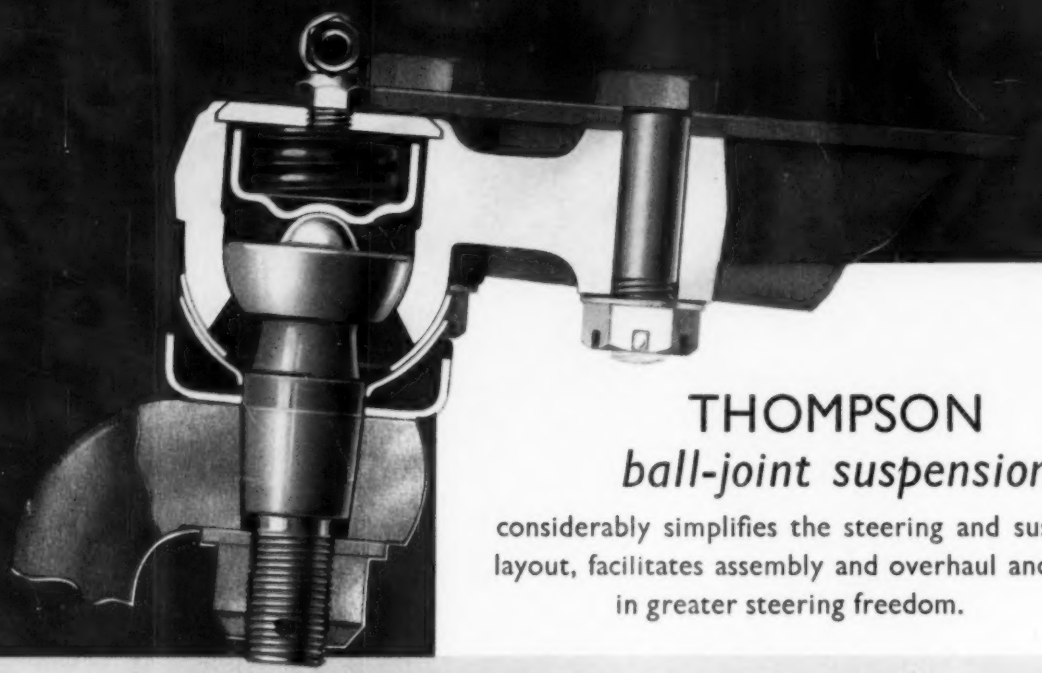

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ball-joint suspension

considerably simplifies the steering and suspension layout, facilitates assembly and overhaul and results in greater steering freedom.

EFFICIENT SIMPLICITY

The upper joint is non-load-carrying and serves the double purpose of providing the second 'king-pin' bearing and the necessary articulation for the suspension linkage. Both joints are self-adjusting.

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AUTOMOTIVE PRODUCTS COMPANY LIMITED,
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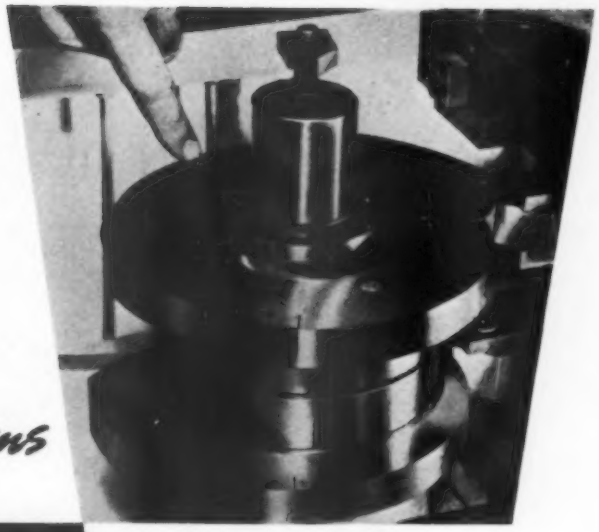
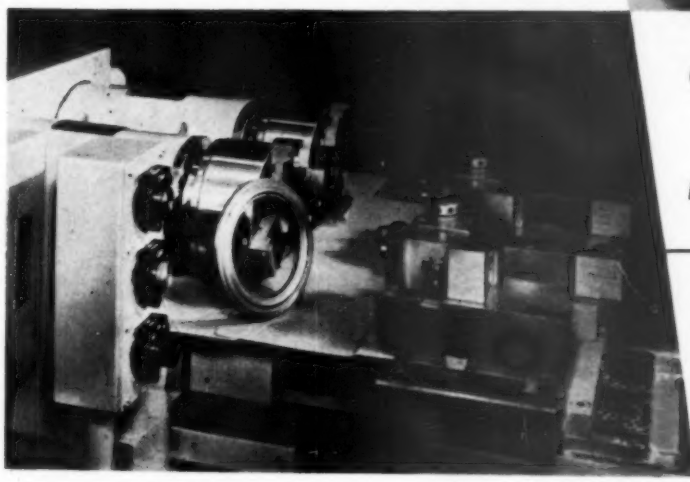
The Simple Approach

to **CONTOUR**

FACING *and*

BORING *problems*

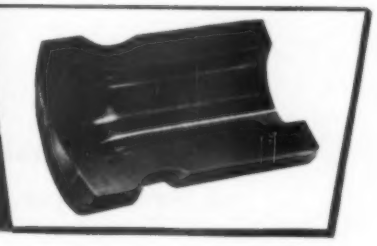




CAMS *PUT THE*

PRECISION

INTO PRECISION BORING!



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When working to "tenths" cams are the best method of maintaining accuracy, because cam control of the tool is *positive* control. The accuracy of parts produced on New Britain boring machines can't be affected by variable hydraulic pressures, ambient temperature, or play in complicated linkages.

With positive cam actuation in one direction and an air cylinder opposing, the cam provides positive control throughout the operating cycle. A single point tool performs all straight boring and turning as well as generating contours. Work and tools can be mounted on the table or in the spindle.

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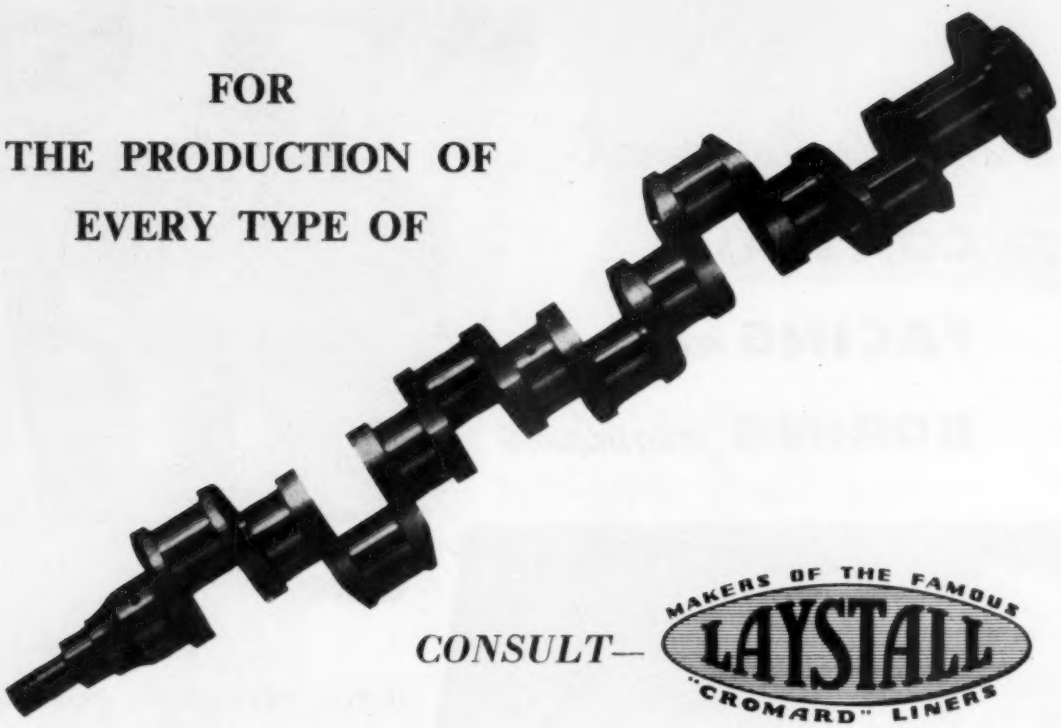

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. . . and it takes more than one success to make a business. While we won't go through a full list of our successes in the past (let's just say that several very well known concerns are our regular customers), if long experience in the highest quality precision moulding is what you're looking for, plus the capacity to turn out a job bang on time, contact:

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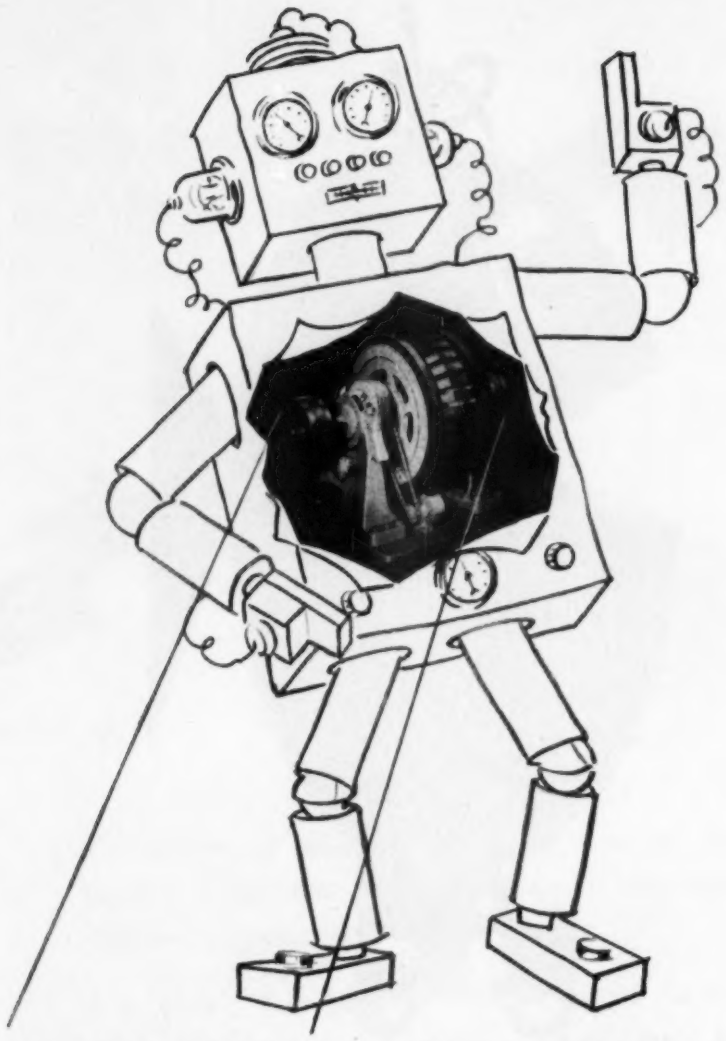
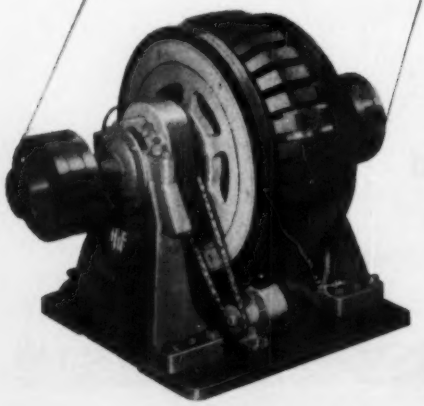


At the heart of Automation will be—



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Variable speed

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SAFER MOTORING

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PATENTED **DISC BRAKES**

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Wickman speed and reliability

Vauxhall production

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Differential Pinion
48 seconds

Thrust Washer
22 secs. for 2

Generator Pulley Hub
27 seconds

Bearing Retaining Ring
24 seconds

CHUCKING Production

Oil Pump Gear Blank
60 secs. for 2

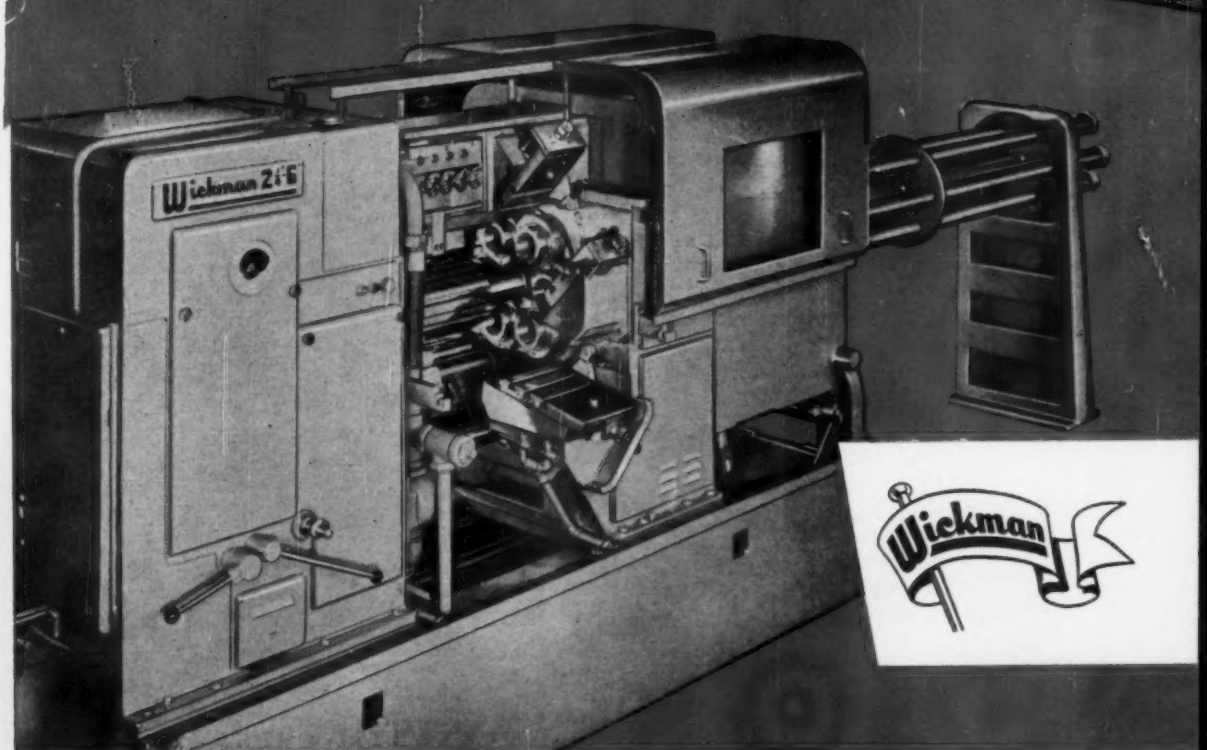
Universal Joint Flange
130 secs. 2 ops.

Piston
11 seconds

Gear Box Front Cover
27 seconds

Differential Side Gear
145 secs. 2 ops.

Typical work examples



Wickman

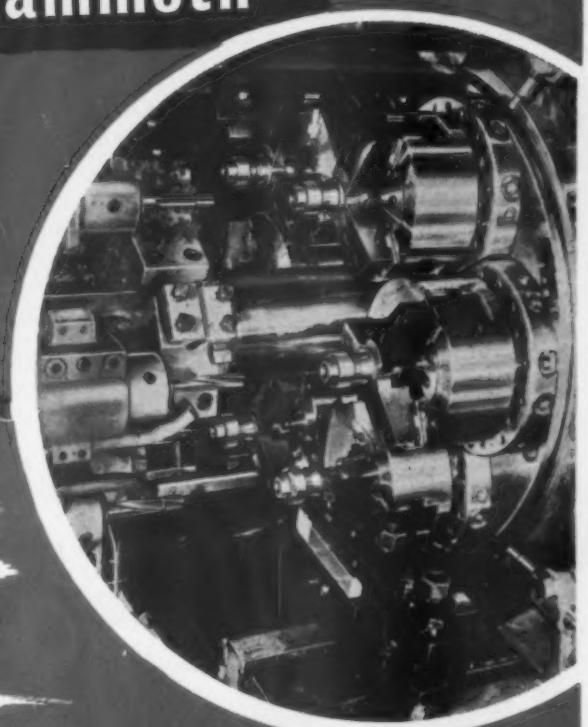
contribute to mammoth programme

Bearing Spacer Adaptor
41 seconds

Speedometer Driving Gear
24 seconds

Differential Case
110 secs. for 2 ops.

Differential Case Cover
78 seconds



Wickman 6½"-6 Chucking Machine producing oil pump gear blanks

To maintain the regular flow of component parts required for their vast programme of car and commercial vehicle production, Vauxhall Motors rely upon multi-spindle bar and chucking automatics.

The two characteristics of high output and consistent accuracy make these machines ideal for mass production, and because they require the minimum of manual attention and occupy little floor space they are among the most economical metal-working machines available today.

Your components, too, could probably be produced quicker and better on a Wickman automatic, and save you money. May we look into it, with you?

Multi-spindle BAR and CHUCKING automatics

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leadership in the field of worm gear manufacture.

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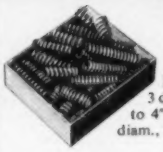
No. 760. 3 doz. Assorted Light Compression Springs. 1″ to 4″ long, 22 to 18 S.W.G., ¼″ to ½″ diam. **6/6** each.



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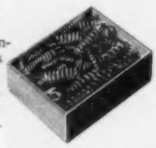
No. 757. Extra Light Compression, 1 gross Assorted, ½″ to ¾″, ½″ to 2″ long, 27 to 20 S.W.G. **15/-** each.



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No. 1024. 20 Compression Springs 12″ long. ¼″ to ½″ diam., 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansions 1¼″ to 12″ long, 5/32″ to ⅜″ diam., 22G to 16G. **24/-** each.

. . . compression, 18 S.W.G. x $\frac{5}{16}$ x 2″, 17 coils?

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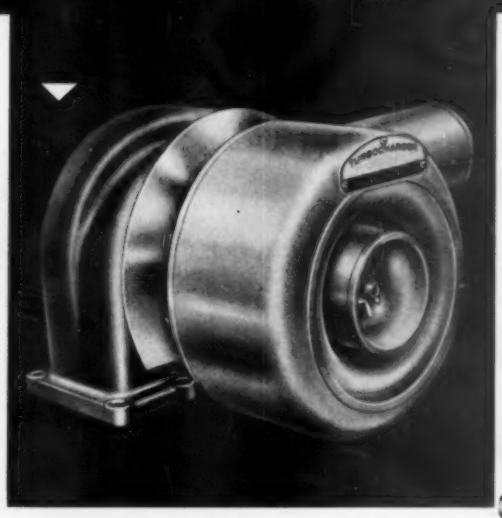

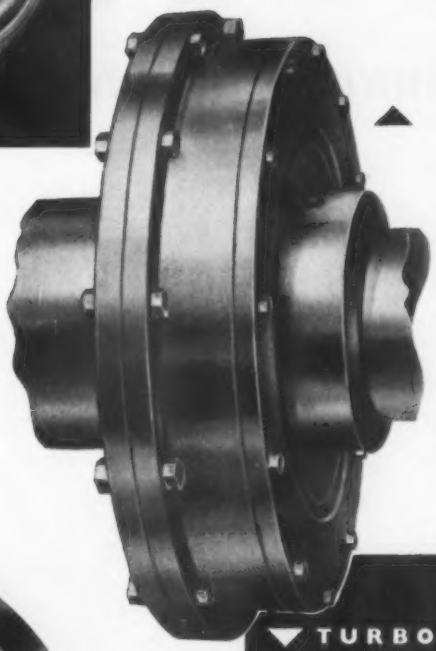

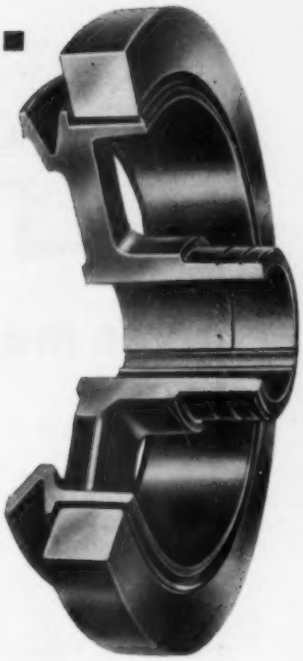

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A combined damper and pulley unit means lower costs on automobile applications. Increased reliability and freedom from bond failures. Designed to suit individual requirements.

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The Holset range covers all types of resilient couplings, including shear pin, slipping, spacer, spider, cardan shaft, turbine and low dynamic stiffness (soft) couplings for all powers and service conditions.

● **VISCOUS CRANKSHAFT DAMPERS**

For Industrial, Locomotive and Marine Engines of any size and any power. Reduces torsional vibration amplitudes and stresses to the lowest possible values.

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The four 2-way horizontal and one single way horizontal hydraulic machines — each with one load and two work stations, as illustrated, are a part of a complete transfer lineup designed to perform all machine operations on automotive transmission cases for a large American plant. With a production schedule of 80 automotive transmission cases per hour this lineup drills, reams, counterbores, countersinks, rough bores, semi-finish bores and taps holes in both the single and double bore sides of case. Automatic turnover fixture is provided, prior to last machine in lineup, to index case into exact position for tapping all holes in bottom face.

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THE 600 GROUP

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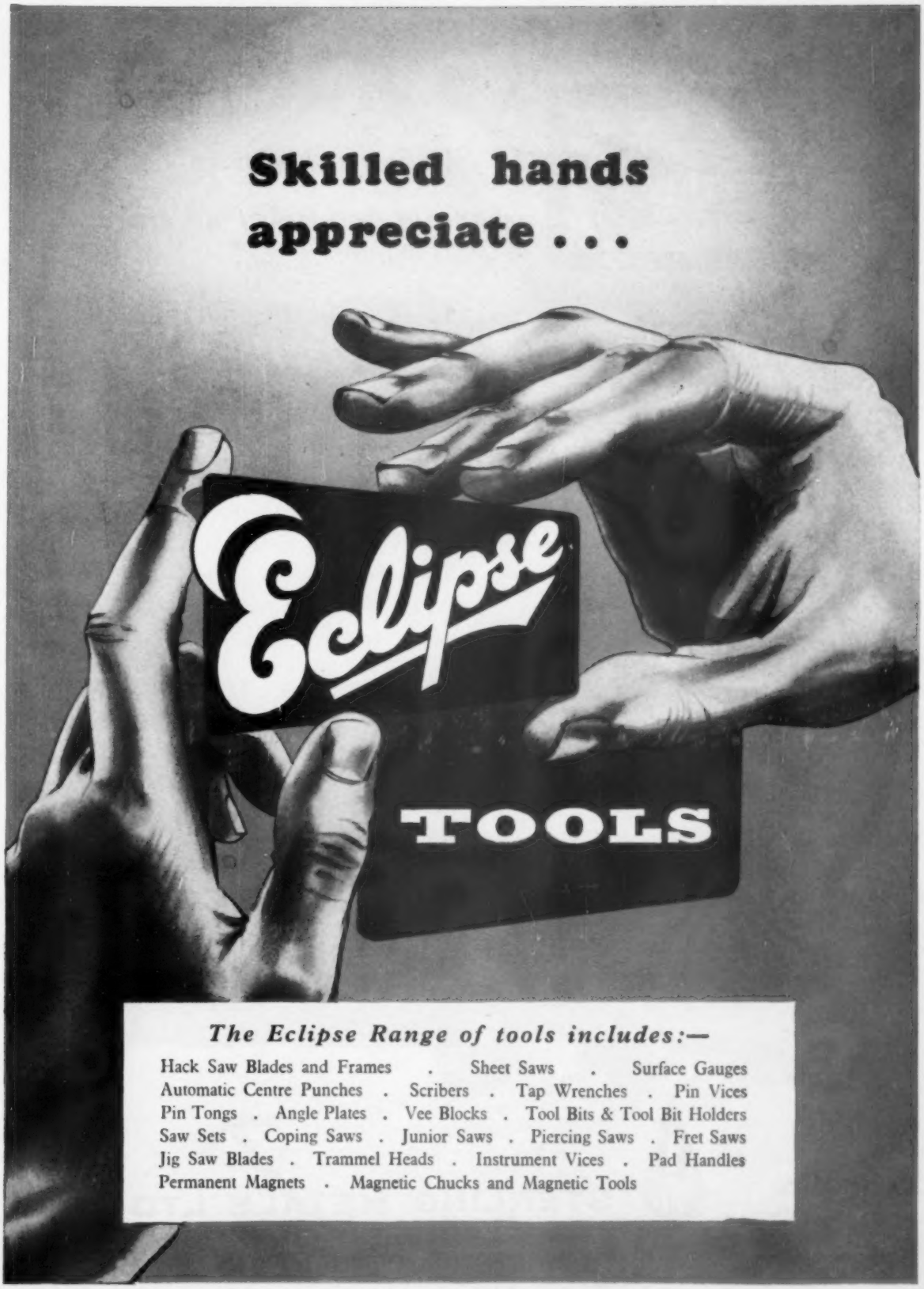

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Made by James Neill & Co. Sheffield Ltd., and obtainable from all tool distributors

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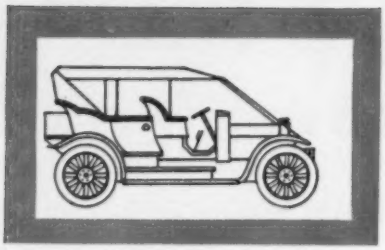
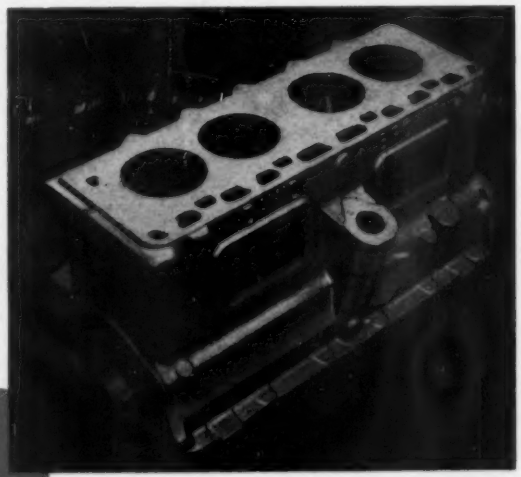


Sterling achievements span the history of an era

. . . and help to make that era memorable.
The continuing success of Sterling Metals is due to their ability to supply castings of the highest quality in the desired quantities at the right time.
Today as in the past, Sterling Metals offer the greatest technical experience augmented by quality control of production which is second to none.
Sterling Metals are the acknowledged experts in casting aluminium and magnesium alloys by sand, die and precision mould processes, and in making engine blocks and cylinder heads in high duty iron.

Sterling Metals are at your service

Cast iron cylinder block
for DB 25 tractor.
By courtesy of David Brown Ltd.



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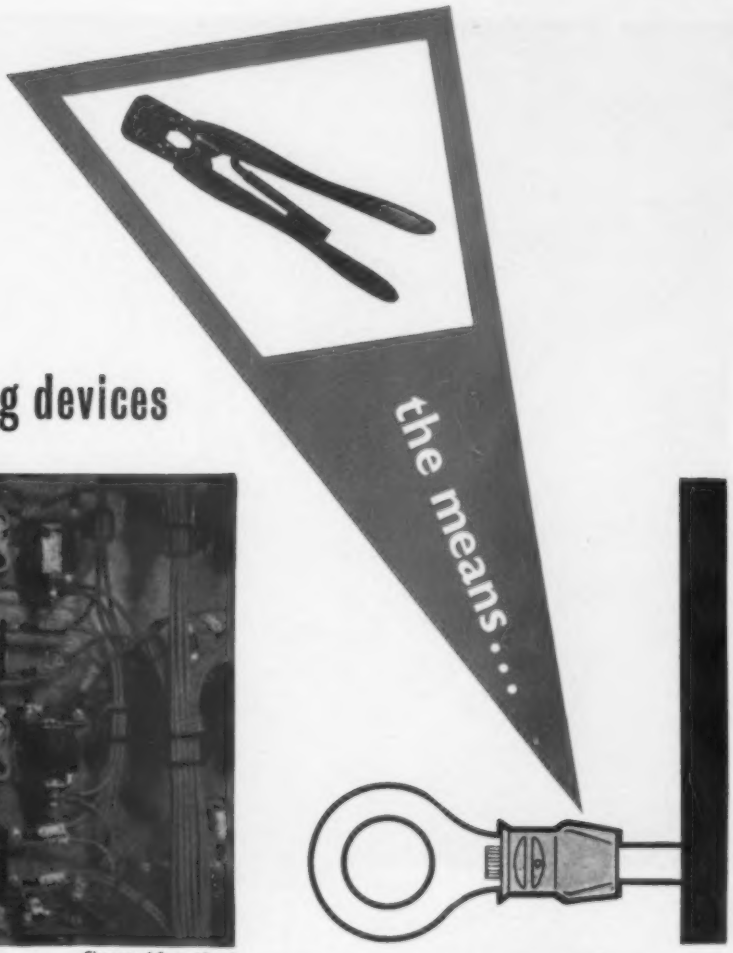
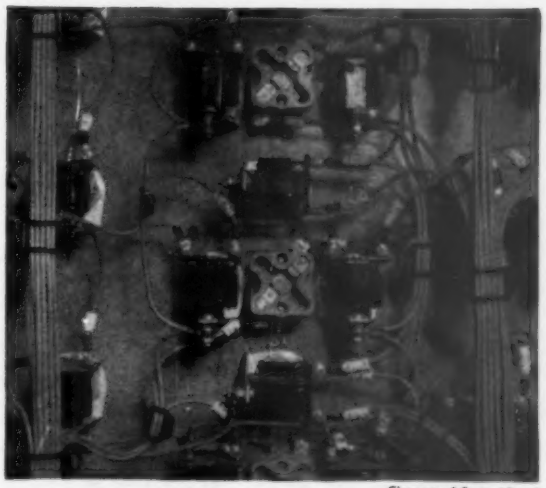
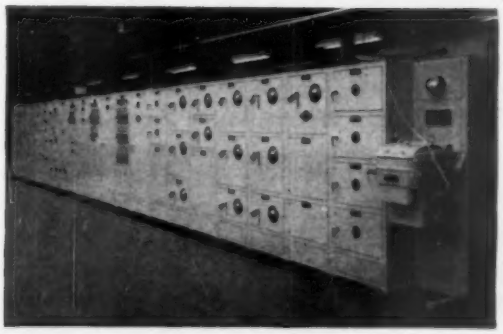




Close-up of Control Panel sub-assembly, illustrating the use of Pre-Insulated Diamond Grip Ring Tongue Terminals



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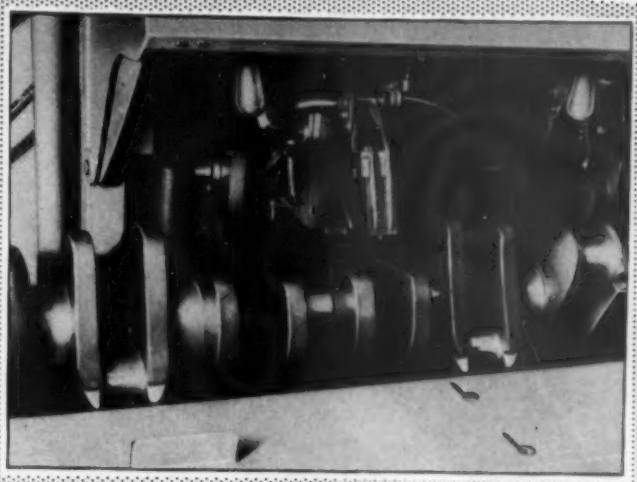

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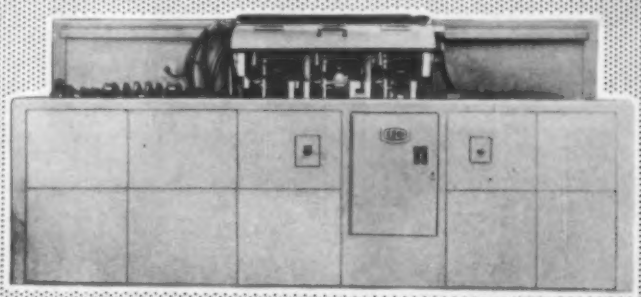

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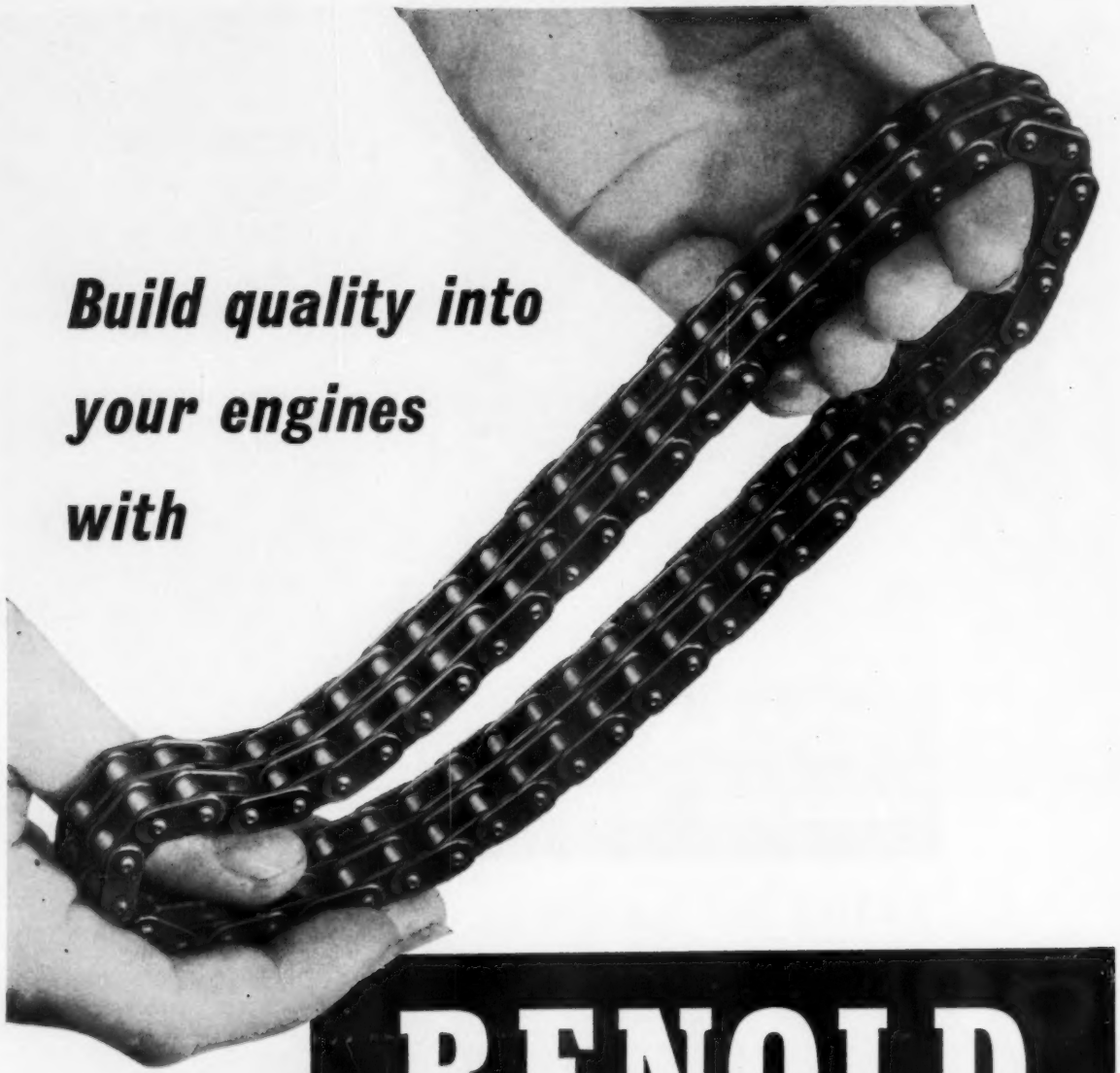

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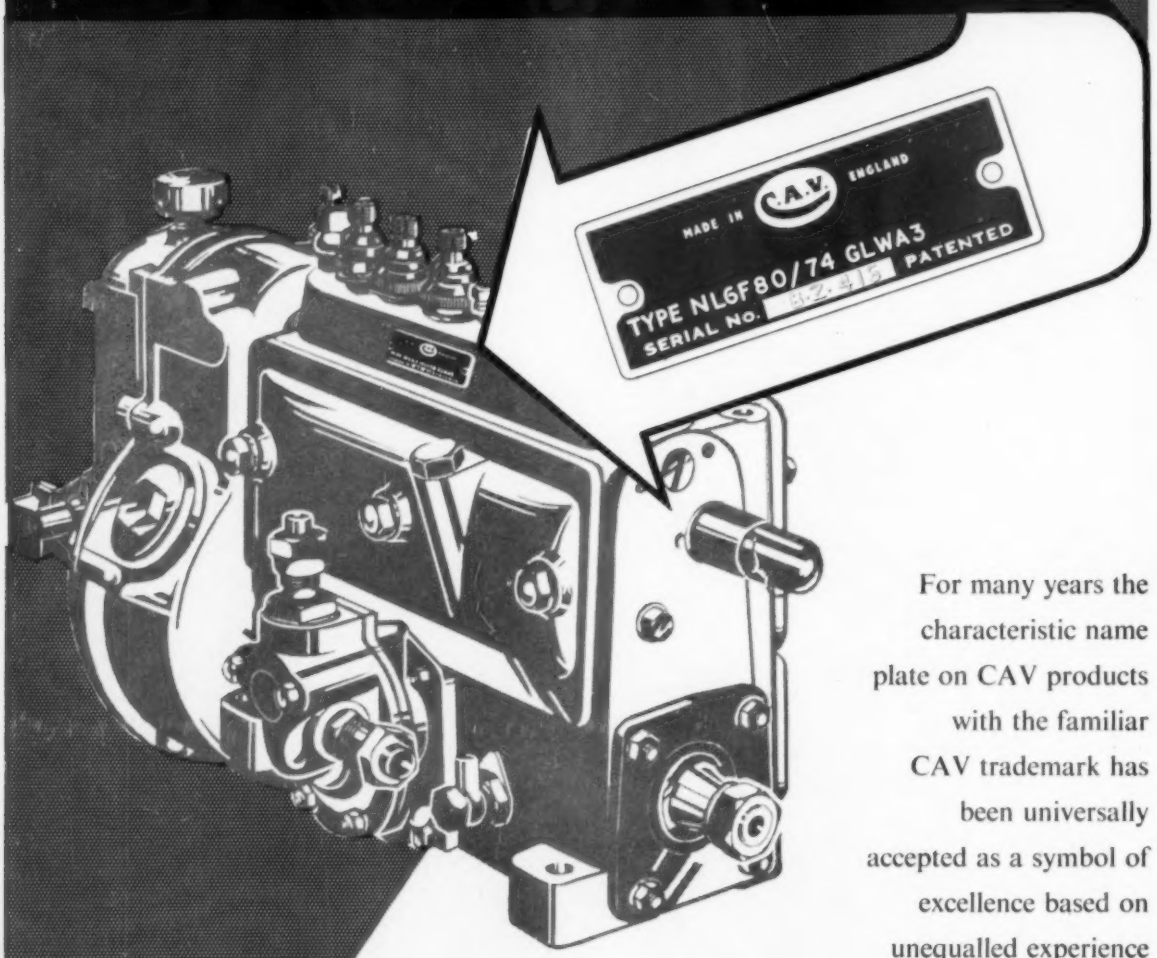

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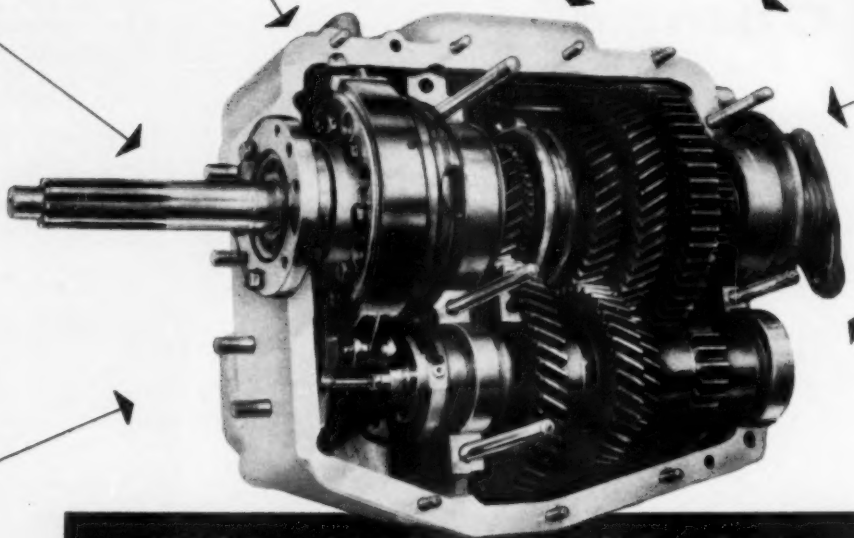

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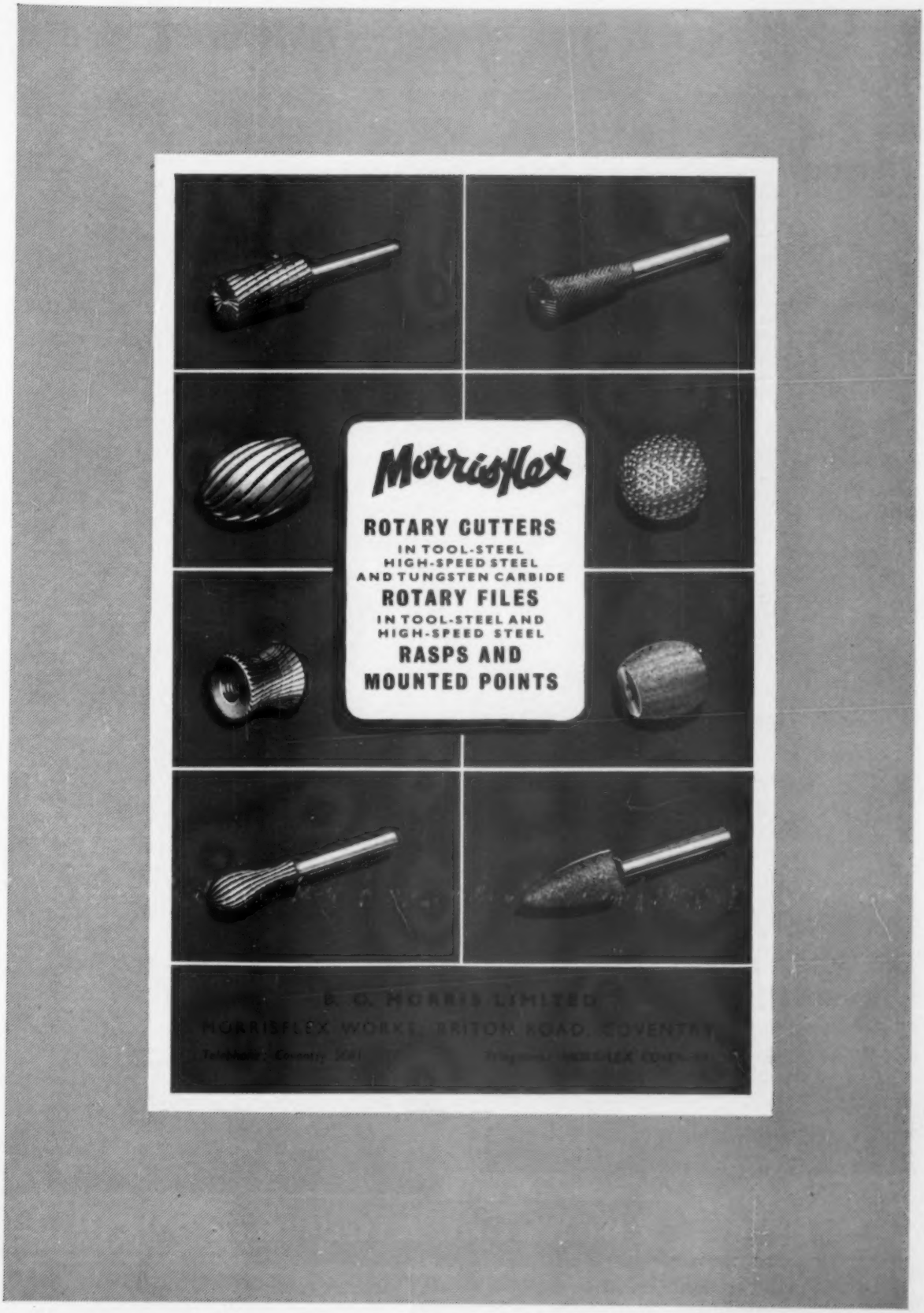
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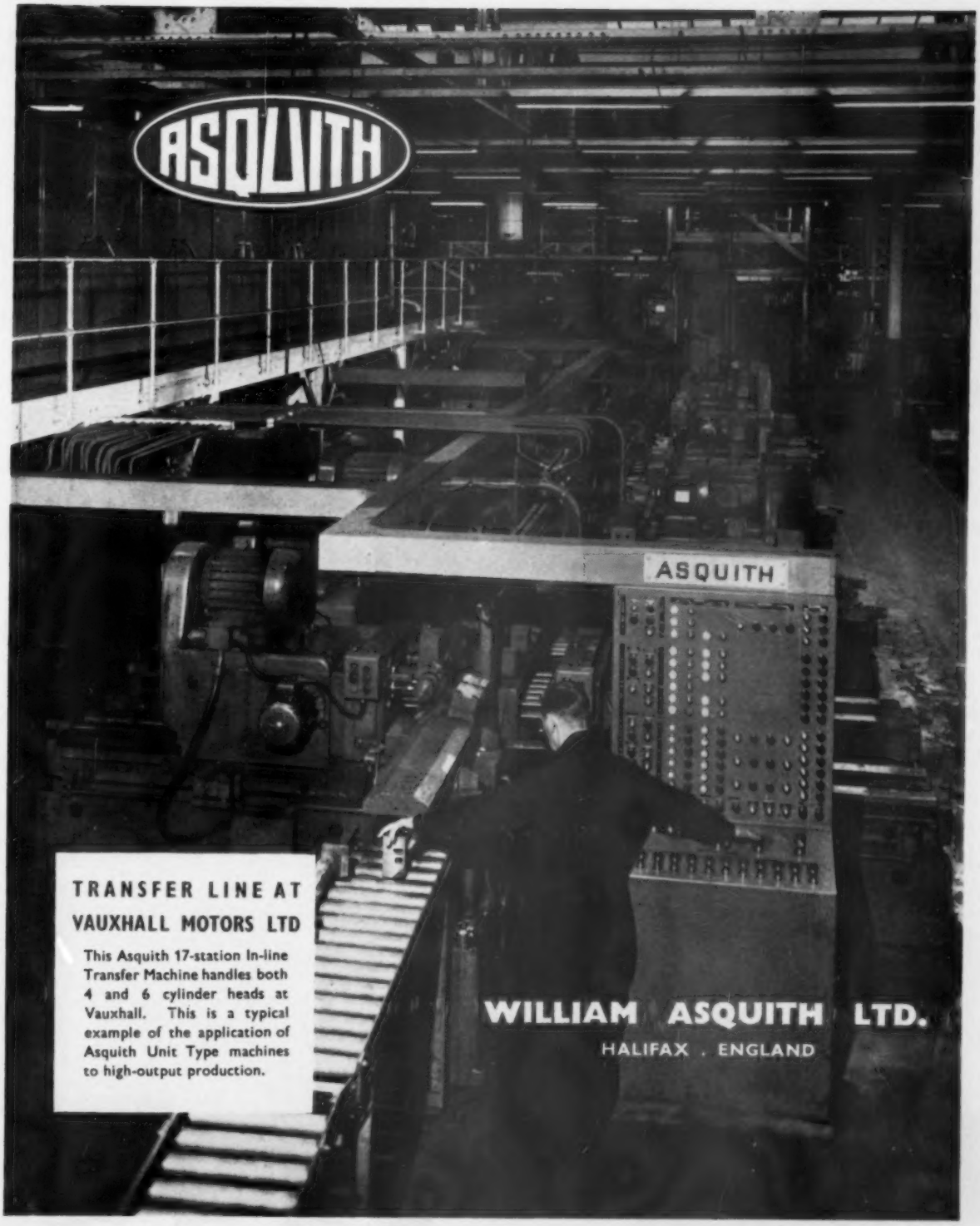
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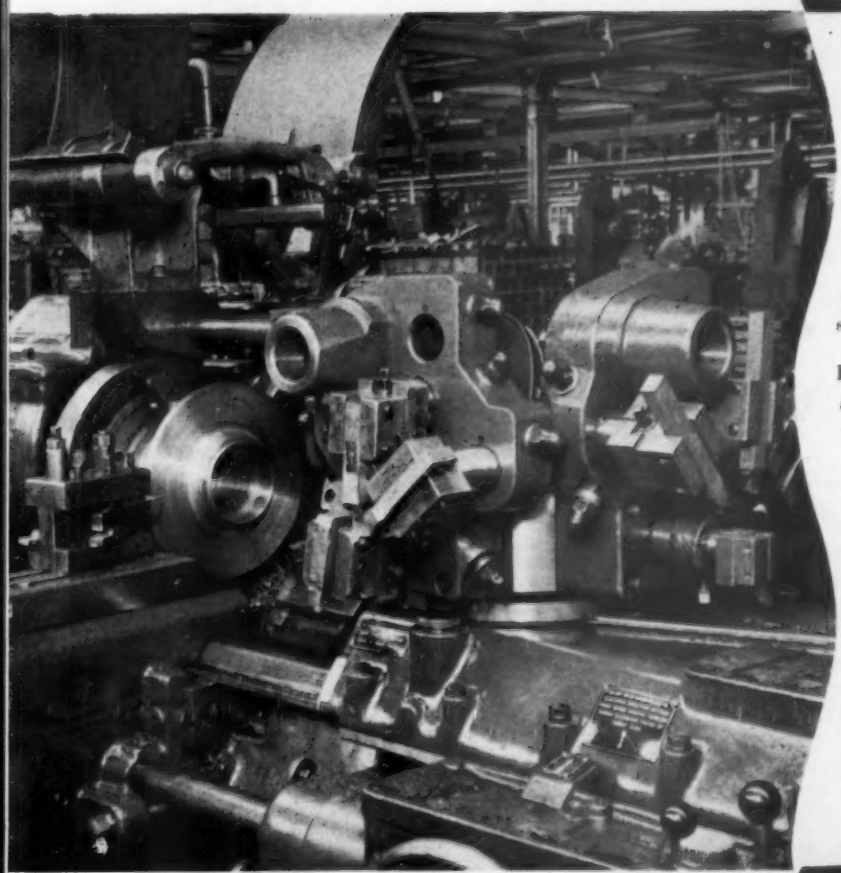

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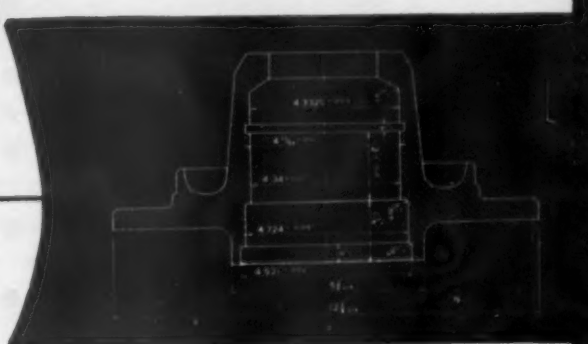

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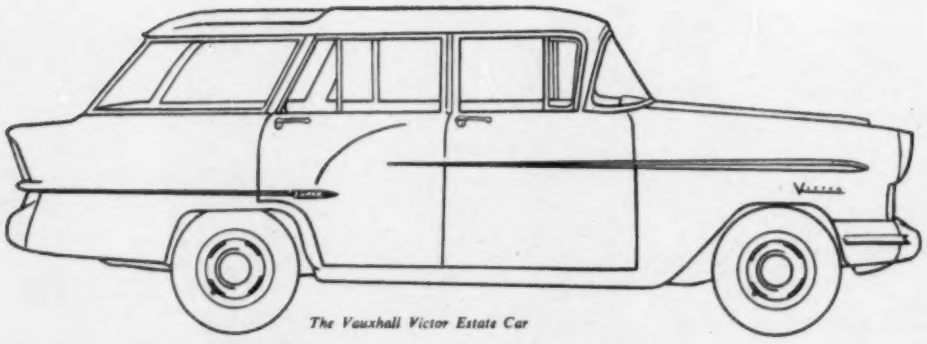

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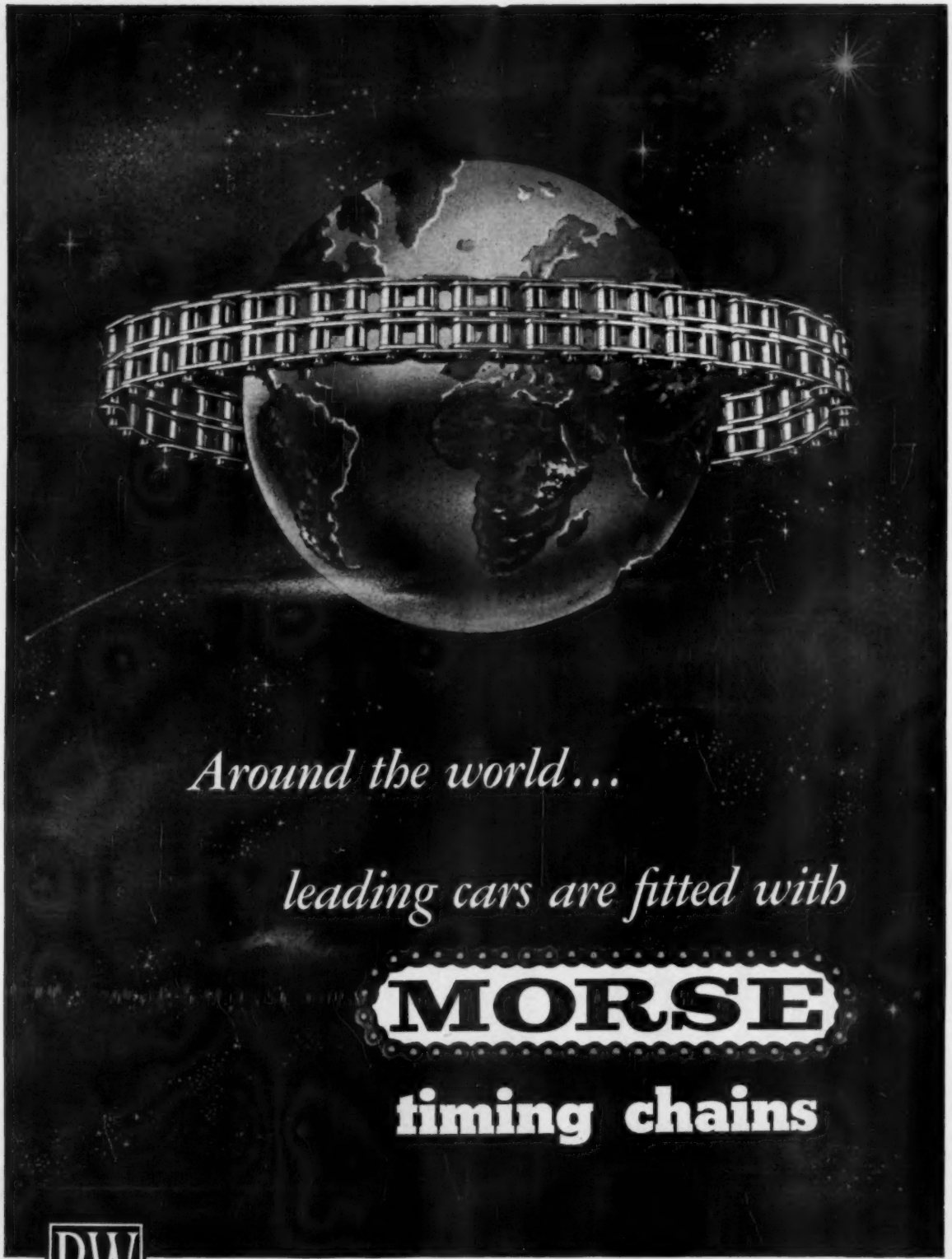

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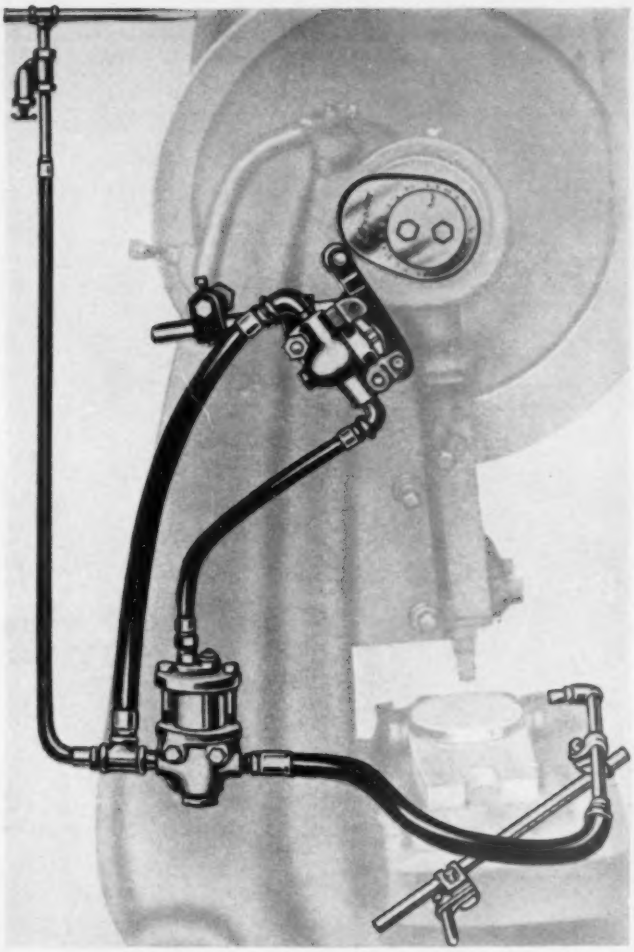

This Air Ejection Set installation shows cam operation off the press crankshaft. It will provide an air blast timed for a fraction of a second, or longer, at any desired point in the press cycle. If required the air blast can be continued after press motion has ceased.

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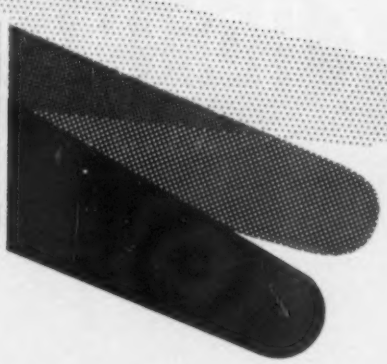

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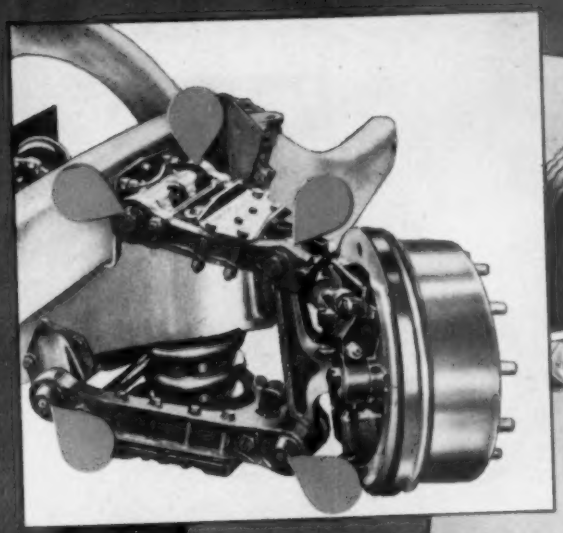
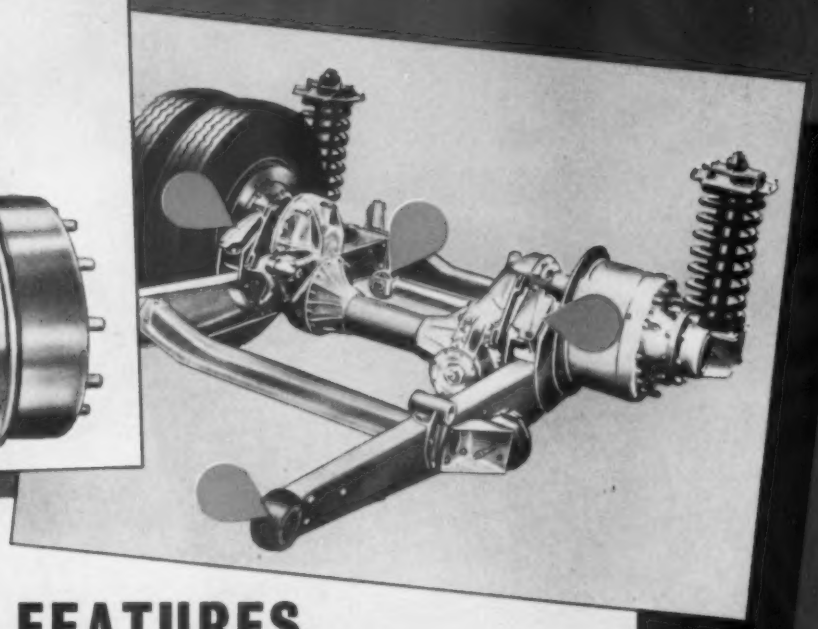




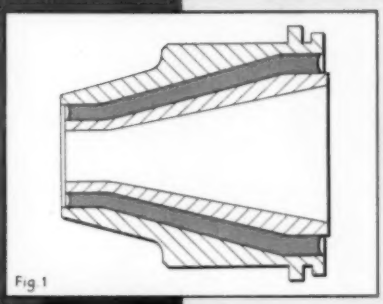


Fig. 1

FEATURES OF INTEREST ON L.T. ROUTEMASTER AND A.C.V. BRIDGEMASTER

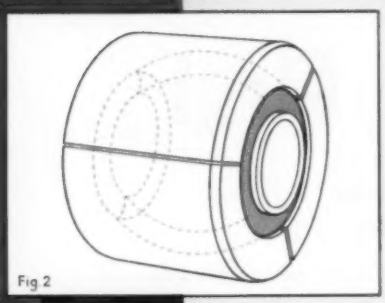


Fig. 2

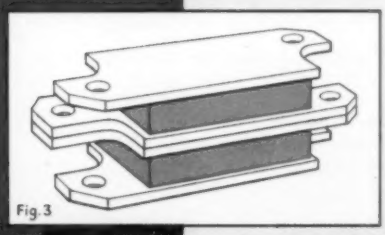


Fig. 3

These interesting vehicles have independent front suspension with coil springs and wishbones.

The wishbone pivots have Metalastik heavy-duty conical bushes, as shown in the sectional drawing (Fig. 1). These are an important factor in making this type of suspension practicable on a heavy vehicle.

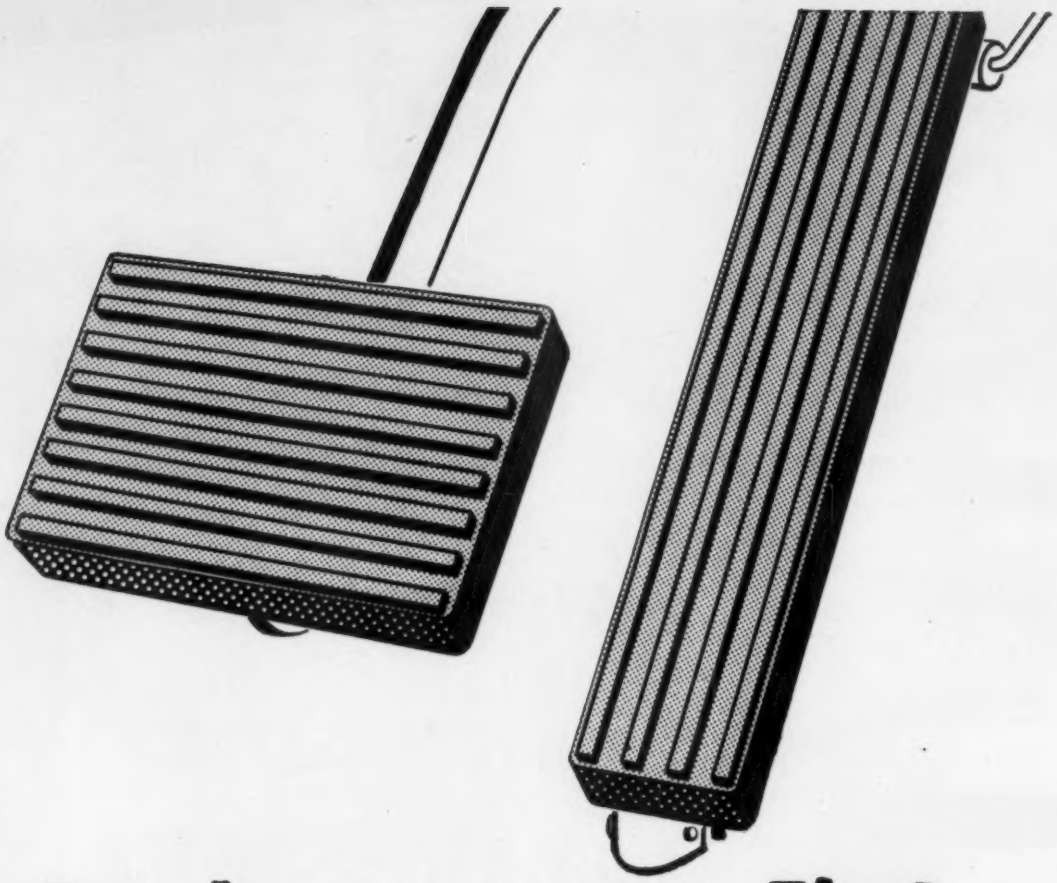
On both vehicles the rear suspension has two substantial trailing arms pivoted to the main suspension members on Spherilastik self-aligning bearings (Fig. 2). The axle assembly is mounted upon the trailing arms by Metalastik sandwich mountings (Fig. 3) at each end. The mountings are arranged in an inverted V formation and permit relative movement of the wheels while increasing roll stiffness and resisting axle wind-up. The transmission of vibration and noise to the structure is reduced by the mountings.

A Panhard rod with a Spherilastik bearing at one end and an Ultra-Duty bush at the other is fitted.

Engine mountings for the Routemaster and the Bridgemaster are supplied by Metalastik.

METALASTIK

METALASTIK LTD., LEICESTER



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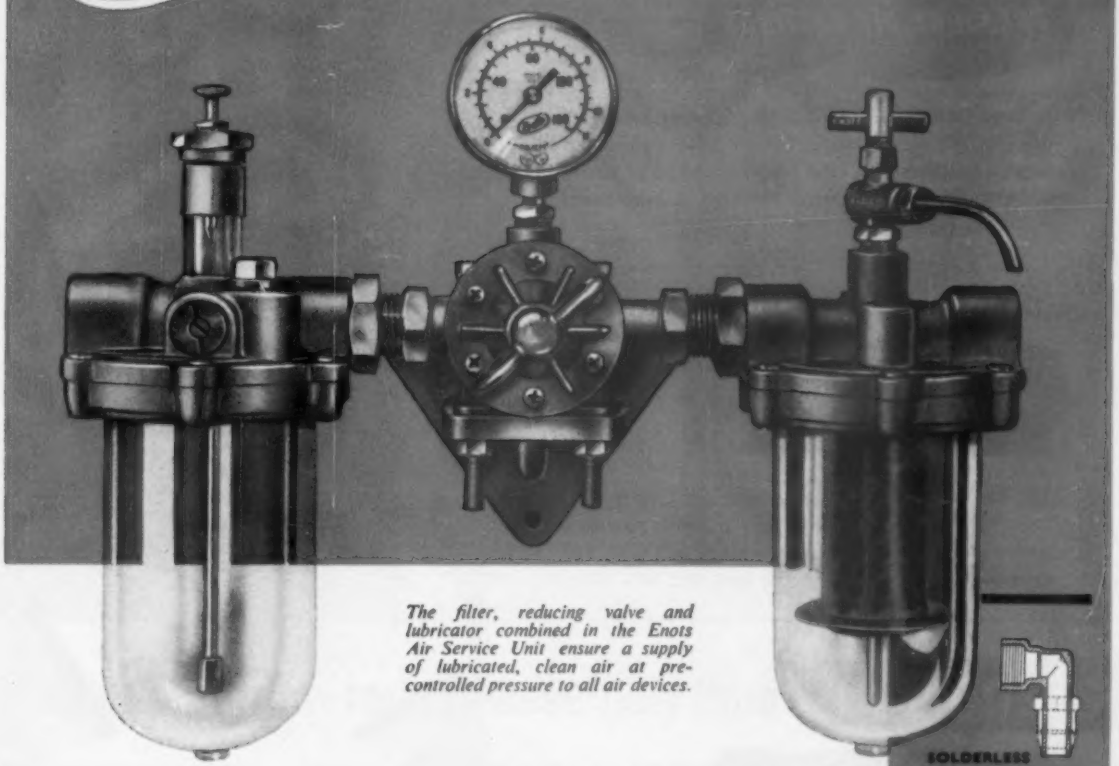
AIR SERVICE UNITS and PNEUMATIC EQUIPMENT

improve efficiency and reduce production costs

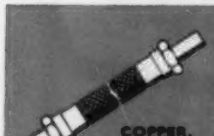


The filter, reducing valve and lubricator combined in the Enots Air Service Unit ensure a supply of lubricated, clean air at pre-controlled pressure to all air devices.

SOLDERLESS UNIONS

BLOW HOSE NOZZLE VALVES

A pressure reducing valve fitted to almost any pneumatic device will save its cost in a very short time by reducing air consumption. At how many points in your works are you using full line pressures of up to 100 lb. per sq. inch where 80, 60 or even lower pressures would be adequate? Savings are more or less in direct proportion to pressure reduction.



COPPER, BUNDY STEEL AND FLEXIBLE TUBES

EXHAUST SILENCERS

QUICK COUPLINGS

EJECTOR VALVES

LEAFLET AS357 describing our Air Service Units and individual components and other catalogues on Enots pneumatic devices are available on request.

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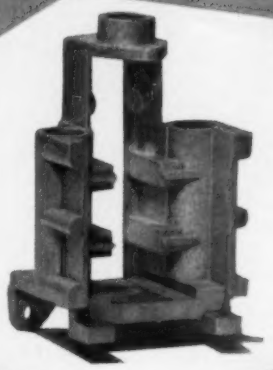
Quality castings in quantity

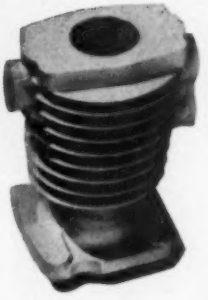
PRESSURE DIE CASTINGS

A large battery of Pressure Die Casting machines can supply quality castings for continuous supply in large quantities—on time. A wide range of alloys are available. This frame is supplied in Zinc-based Alloy BS.1004A.



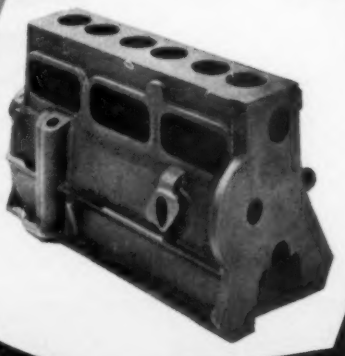
GRAVITY DIE CASTINGS

We have available a large Aluminium Gravity Die Casting Foundry where high quality precision castings are produced in a wide range of alloys. The cylinder shown is gravity die cast in LM.4 alloy.



MECHANISED & FLOOR CASTINGS

The Iron Foundries consist of five mechanised moulding units for castings up to 500 lbs. weight, maximum size 4 ft. x 3 ft. and a floor casting section handling up to 5 tons weight. Careful tests are made at all stages and castings can be balanced and locations machined to reduce machine shop time.
The Aluminium Foundries also include a large mechanised and a jobbing section.



We shall be pleased to help on your next casting problem.

West Yorkshire Foundries Ltd.

SAYNER LANE, LEEDS 10
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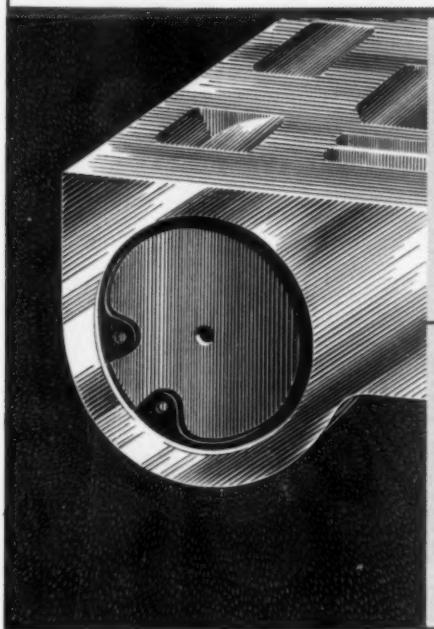
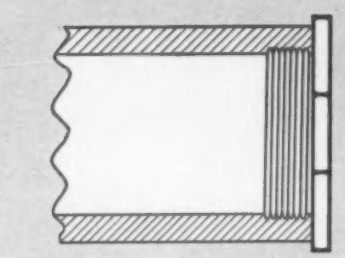
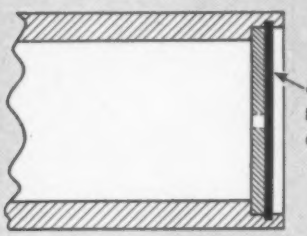
The logical advance in Retaining





OLD WAY

This fluid seal involved internal threading of the tube, which was sealed with an expensive cap-nut. The assembly was laborious and spanners were needed.



THE SALTER WAY

The tube is recessed and then simply grooved with the SALTER Grooving Tool. A Circlip is snapped into position and secures the fluid retaining plate with positive, vibration-free locking. When necessary the Circlip can be removed quickly and easily.

save material–reduce assembly time – cut costs

When it's a question of assembling components in any engineering field, Salter Retainers are the answer. They replace nuts and bolts, screws, cotter pins, and eliminate expensive threading and machining operations. A large standard range is at your immediate disposal, and we should welcome the opportunity to assist in developing special retainers to solve your problems.

Send for the Salter Retainer catalogue — no designer is complete without it.

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SALTER "TRUARC"

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Around 15,000 a day—for cars, vans, buses, trucks, tractors, trailers. Not surprising when you consider that Sankey's, the first to make the pressed steel vehicle wheel, are the largest producers in Europe. Press facilities up to 2,000 tons, welding capacity up to 1,200 K.V.A., specialised conveying systems, full painting equipment—all combine at Wellington to provide industry with everything it requires in the way of wheels.

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Sankey OF WELLINGTON

JOSEPH SANKEY & SONS LTD., HADLEY CASTLE WORKS, WELLINGTON, SHROPSHIRE.
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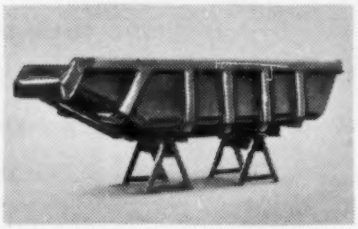
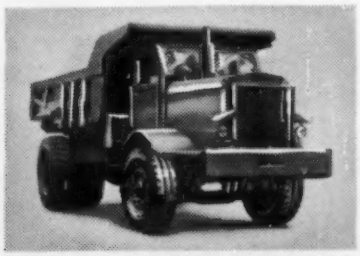
22 ton Euclid Rear Dump being loaded by large mechanical shovel.



The first body produced at Euclid, Newhouse.



Euclid 22 ton Rear Dump

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CARRYING THE LOAD . . .

comes easily to the Euclid 22 ton Rear Dump Trucks specially built for "off-the-highway" heavy duty hauling of earth, rock, and ore on grade variation projects.
To endure this day-in, day-out punishment, heavy construction and first-class design are vital, together with welding that stands up to the continual stresses and strains. That is why the makers chose Actarc "VELVARC" Electrodes, whose superior characteristics are fully recognized by so many of the leading firms in the welding industry.

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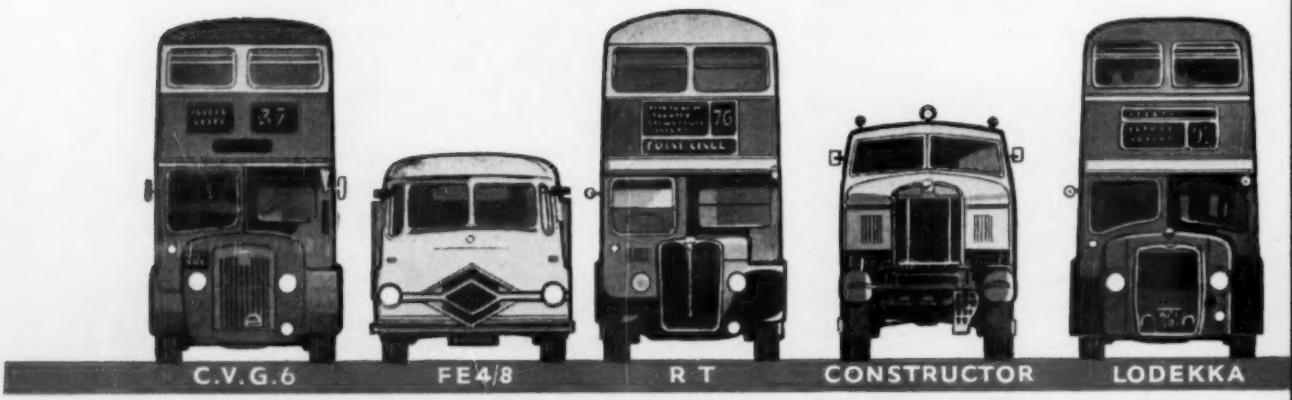

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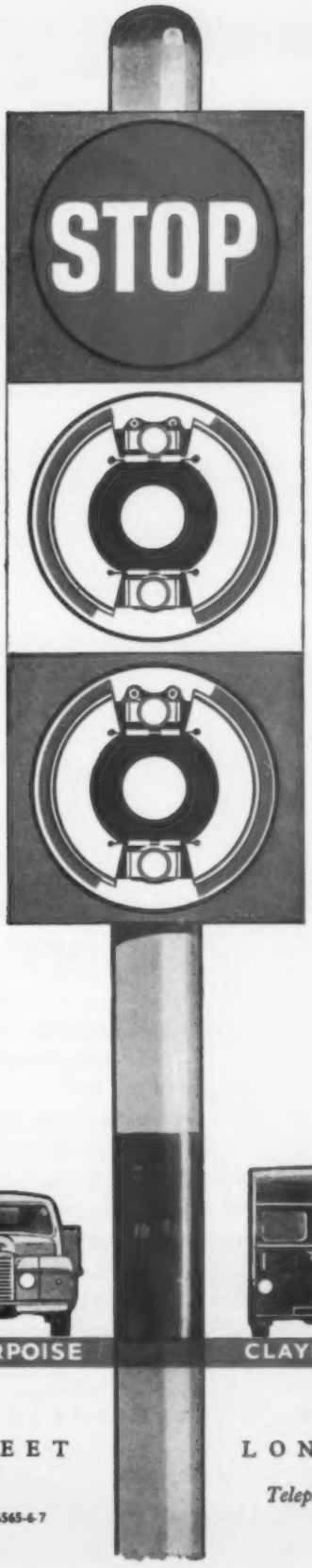

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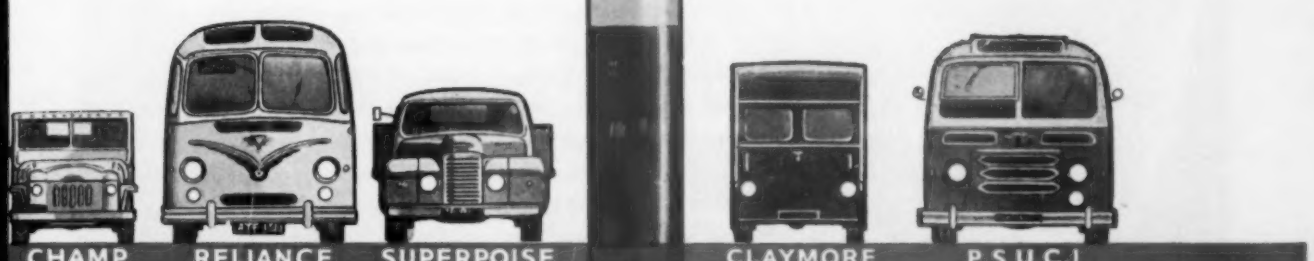

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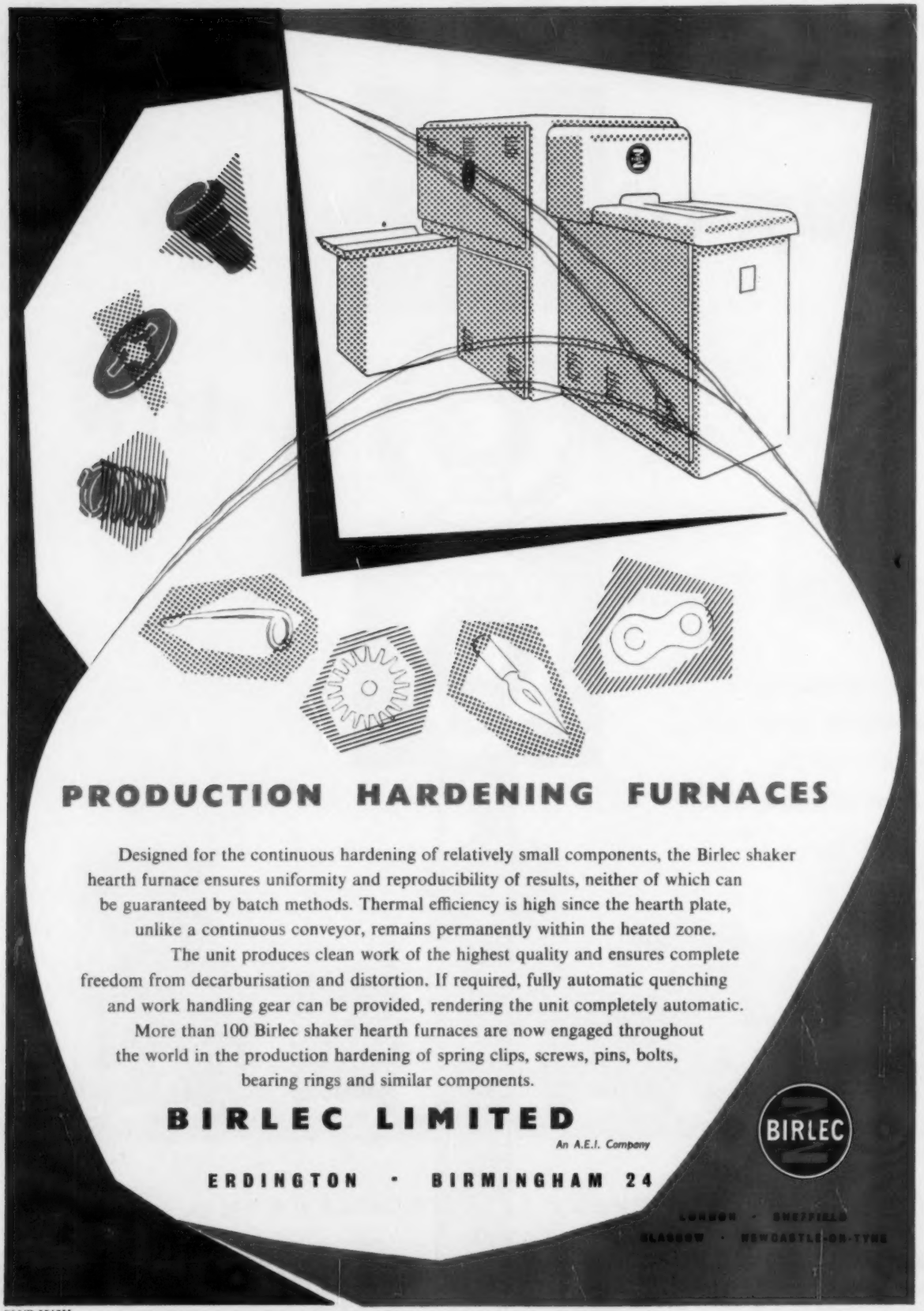

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The unit produces clean work of the highest quality and ensures complete freedom from decarburisation and distortion. If required, fully automatic quenching and work handling gear can be provided, rendering the unit completely automatic.

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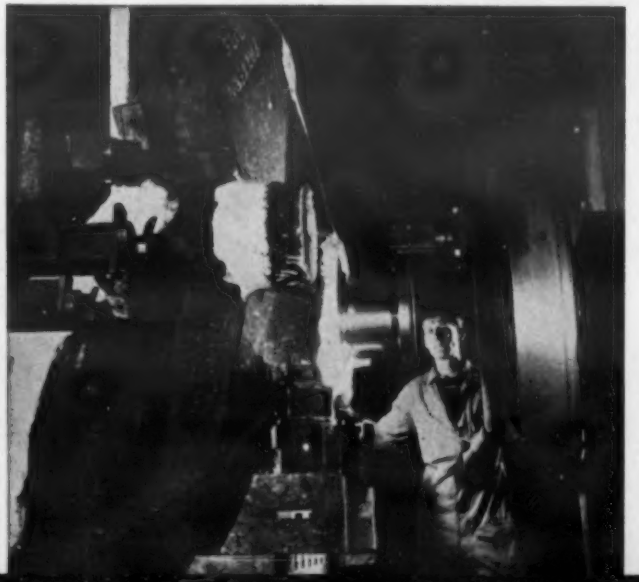

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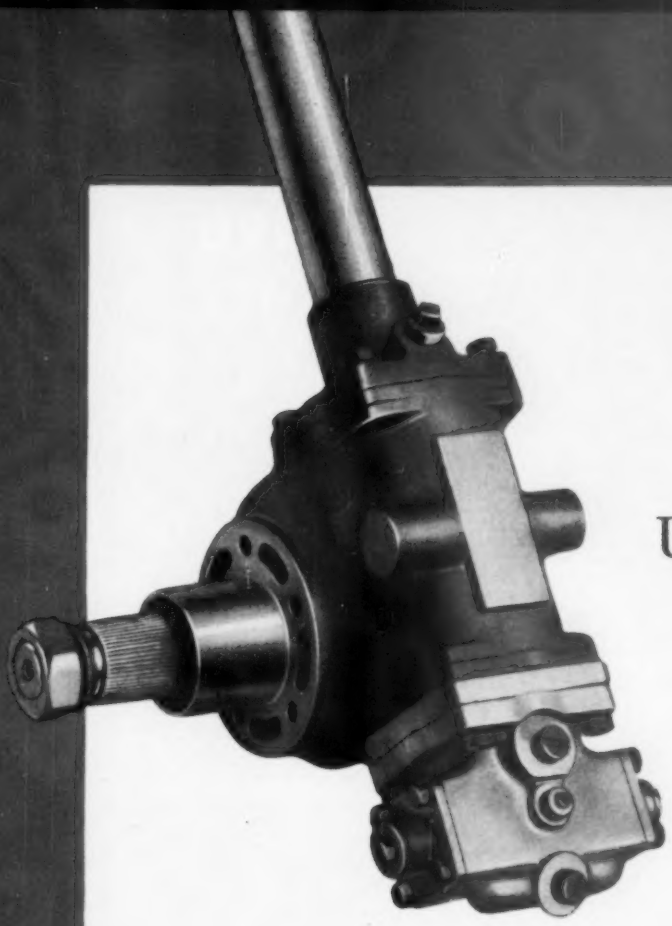

THE UNIVERSAL UNIT

Illustrated above is the Type 3 'Universal' steering gear which incorporates the hydraulic control valves mounted upon our type '861' manual gear. This is for use with a separate power pump and with power cylinders operating on the steering linkage. Further particulars will be sent on request.

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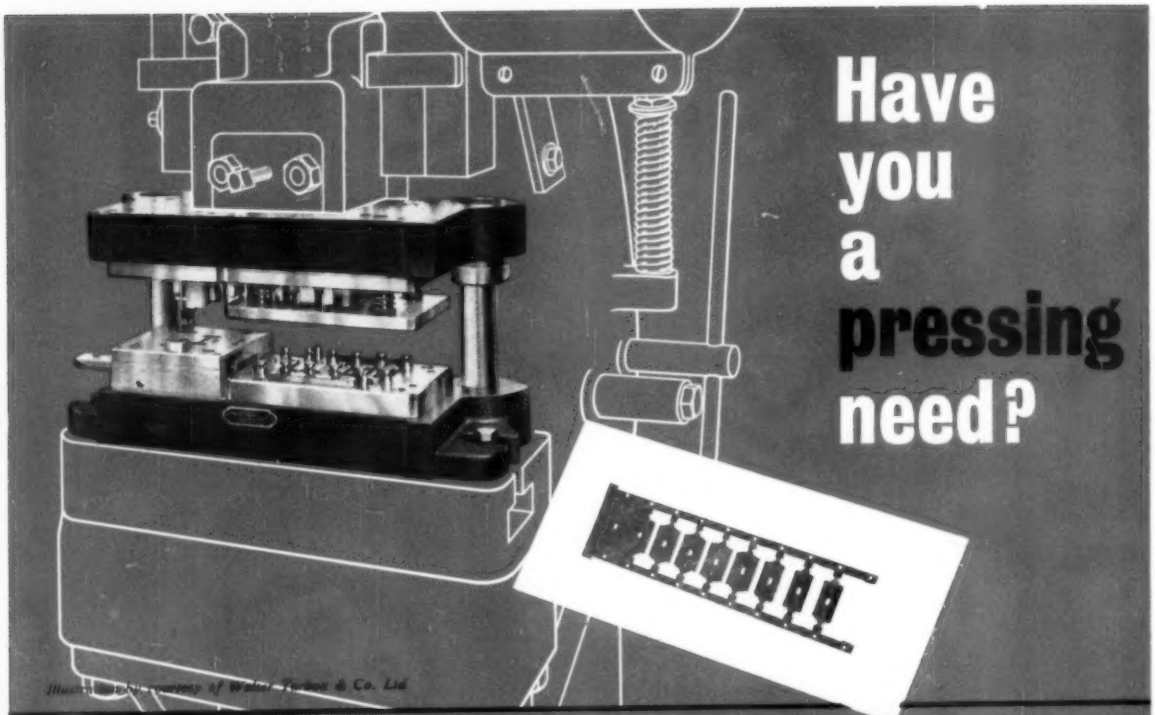

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KE

KE 672 is an excellent general purpose oil hardening tool steel. When worked under normal conditions it is trouble free and ideal for a wide variety of blanking, pressing and piercing operations.

KE 637 is a first class low temperature oil hardening tool steel with deep hardening properties. It is an excellent steel for gauges and tools of intricate shape where final grinding after hardening is not permissible.

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KE 970 is a 2% Carbon 14% Chrome High Duty Tool Steel, used for a variety of exacting blanking and pressing operations. For increased toughness at a slight loss in hardness we supply KE961 1½% Carbon 12% Chrome Steel.

Stocks held in Sheffield and London.

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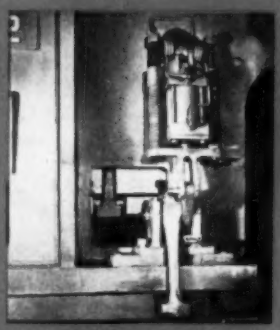
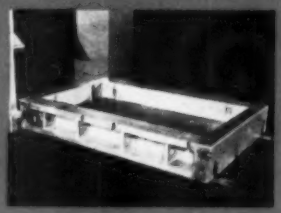
now short run production is economical with . . .

New Quick Die Change Presses



Dies are clamped to press slide quickly, automatically. Shutheight adjustment of slide is dial set within .001 inch.



Each press has two power-driven die carriers that move in and out of work area through upright openings at touch of push button.

DANLY

Danly Quick Die Change Presses have TWO bolsters mounted on power-driven carriers which move into or out of the press through large openings in press sides. This new principle permits the press to continue in full production while another die is set up on a bolster outside. Die change is reduced to a matter of minutes. Ease and rapidity of die change makes controlled production in short runs virtually as economical as long runs. A leading European auto maker uses two complete lines of these presses because they also offer other important advantages:

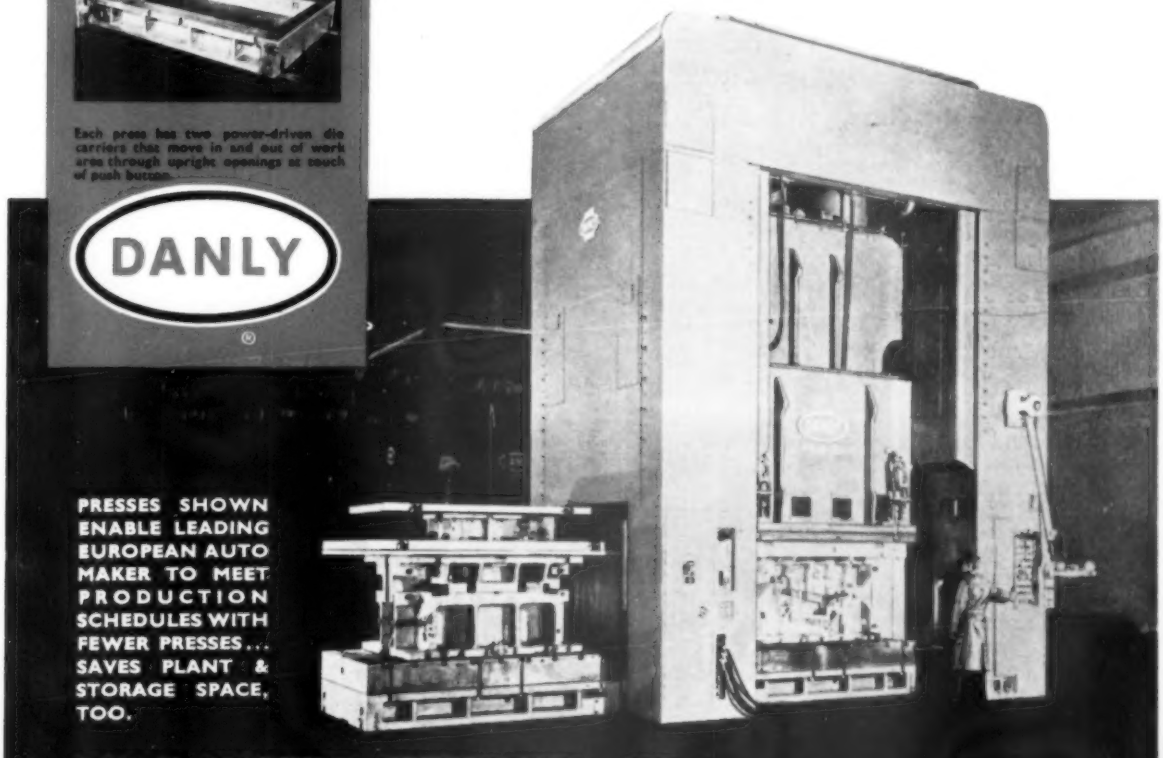
STAMPING PRODUCTION INCREASED OVER 40%. Production time is increased because die change time is reduced. A die can be removed for normal maintenance—and another shuttled into place—with practically no interruption in production.

DIES CHANGED IN 5 MINUTES. A die may be set up in advance on a bolster outside the press. Complete changeover—for one press or an entire line—takes just 5 minutes. Mechanical handling devices between presses remain in place during die change.

FLOOR SPACE SAVED. Presses may be set closer together because dies are changed through press sides. Controlled production also substantially reduces the size of storage banks maintained for assembly lines.

DIE TRYOUT IS FAST AND CONVENIENT. Dies may be tried out in the presses that will actually produce the stampings—under supervision of regular production personnel. Time and money are saved.

See how you can benefit from new Quick Die Change Presses. Bulletin P 43.1 has the facts. Write for it today.



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HB 9547

This bus has a double safety feature in its braking system

THE DENNIS LOLINE—
Photograph by courtesy of Dennis Bros., Ltd.

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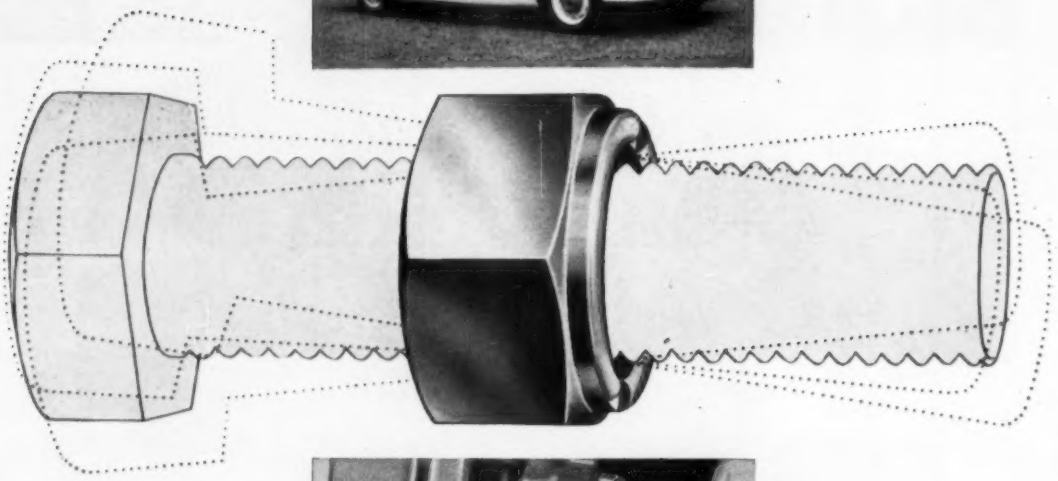

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shake them, soak them—nothing short of a spanner works them loose.
Jaguar Cars Ltd. are using Nylocs on a most critical assembly point
of any car—the steering joints. On the Jaguar 2.4,
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However fast the Jaguar goes the Nylocs won't budge—not even a thou!
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to fit than ordinary nuts with their split pins and whatnot.
Nylocs could do a good job for you—or would our Pinnacle or Fibre nuts
be more suitable? Drop us a line and we'll gladly advise you.

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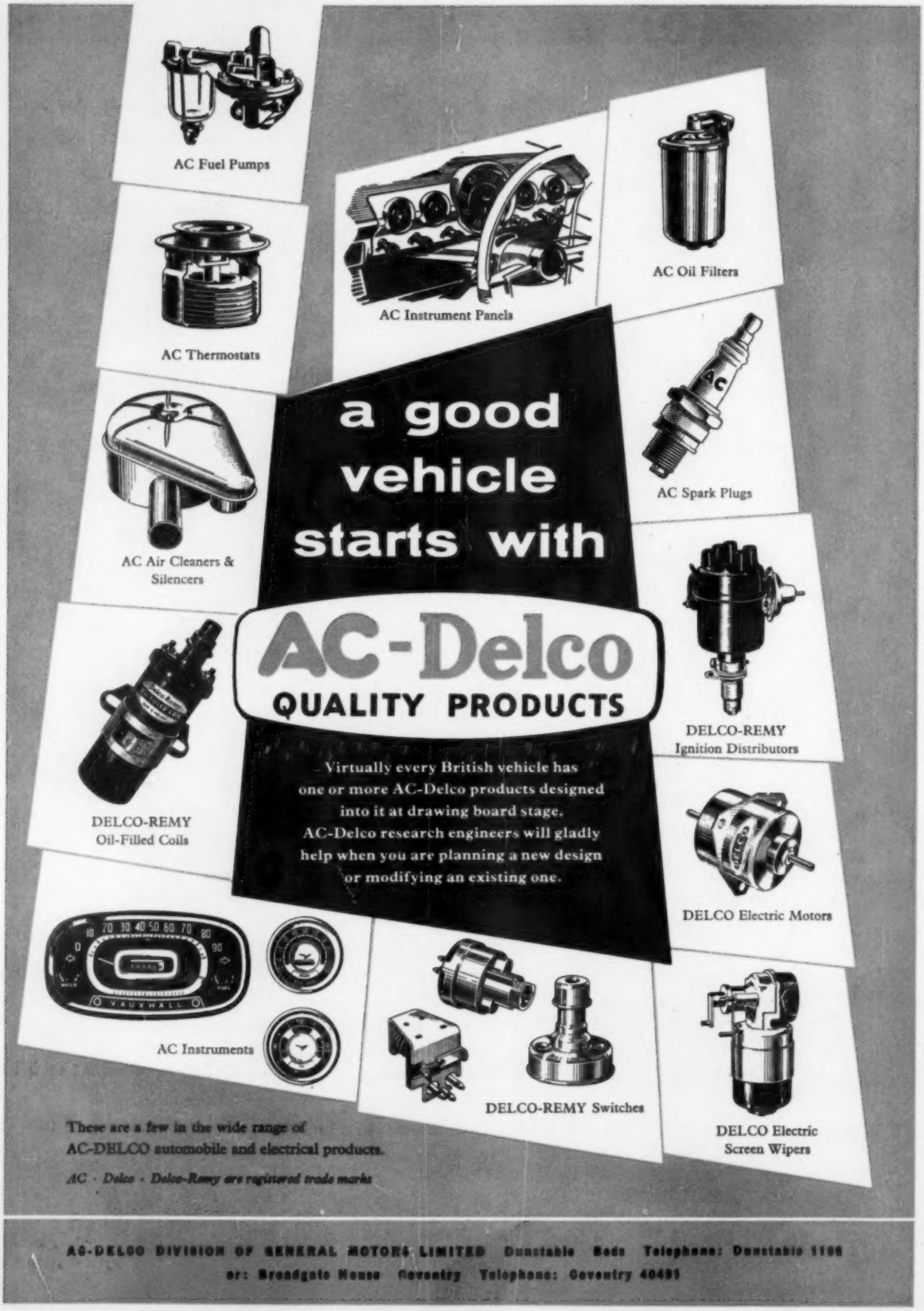
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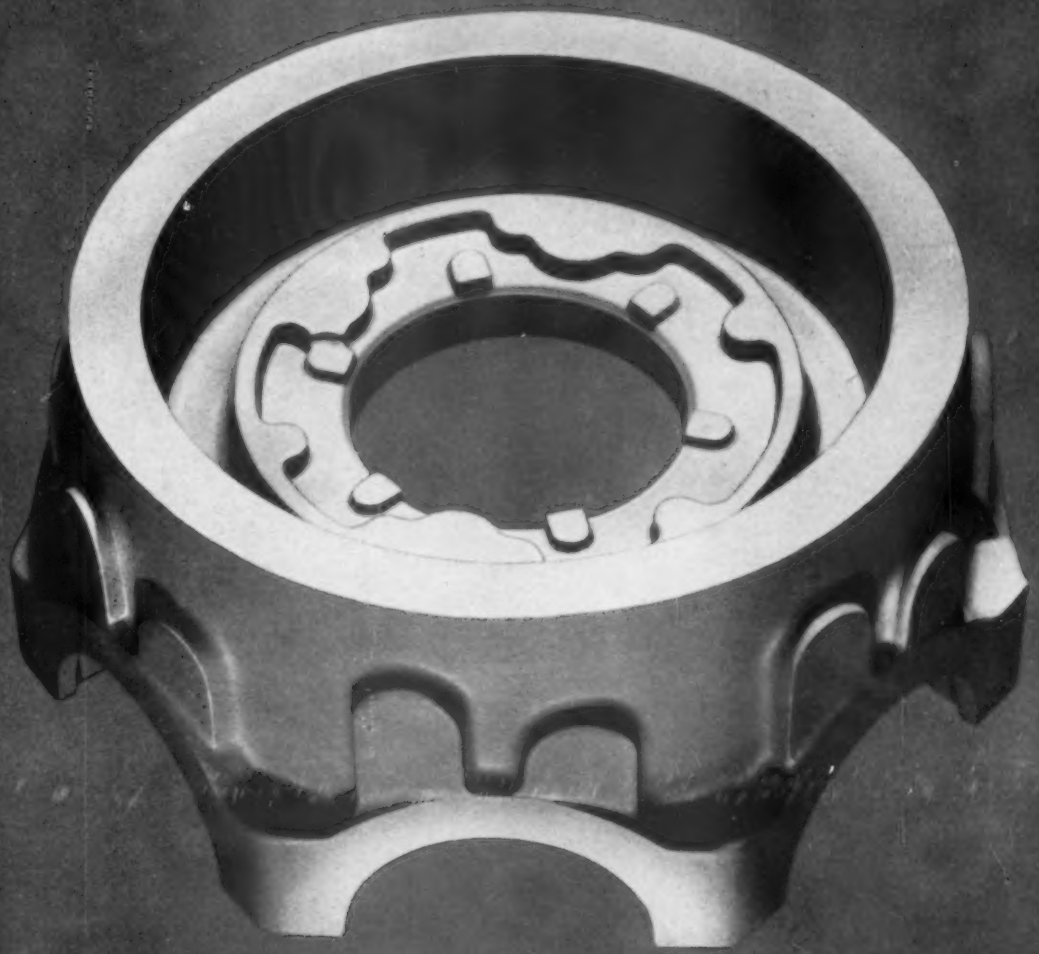

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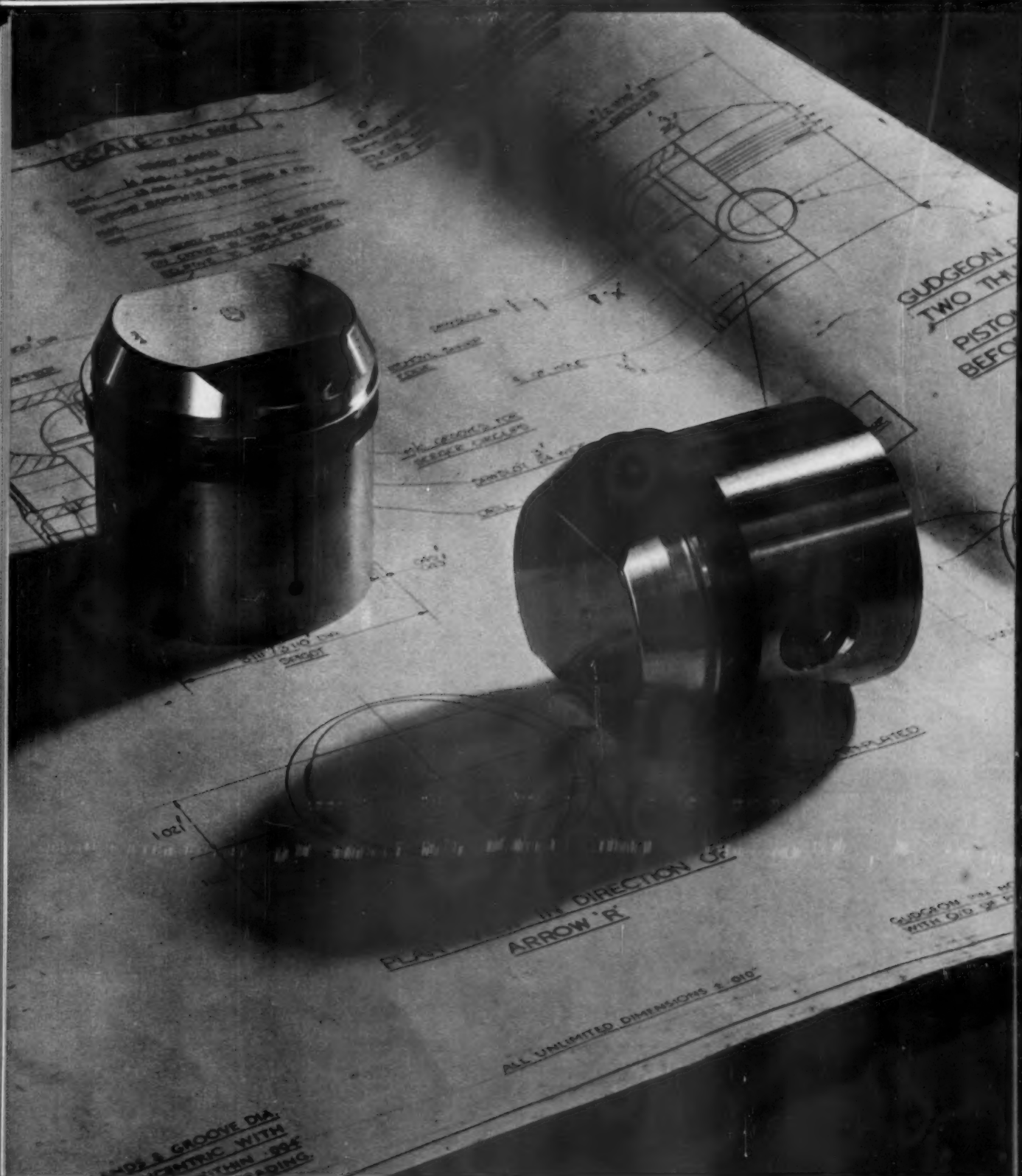

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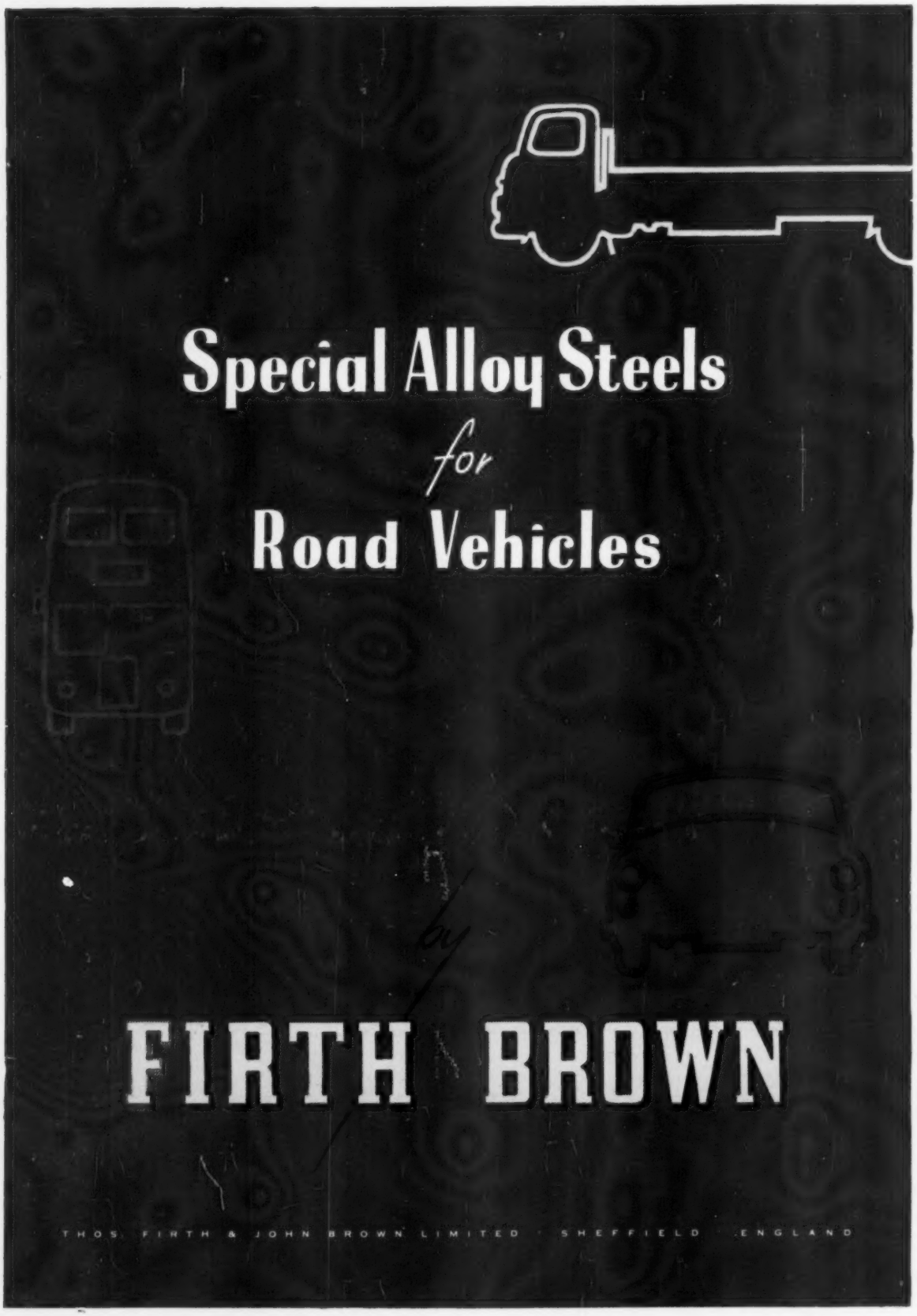
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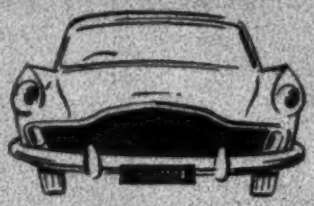

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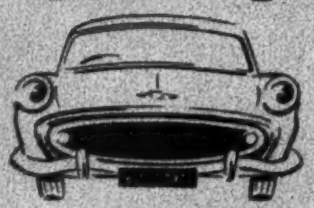

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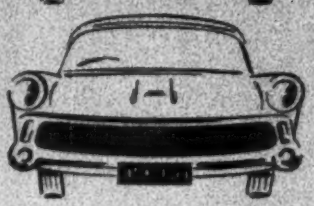

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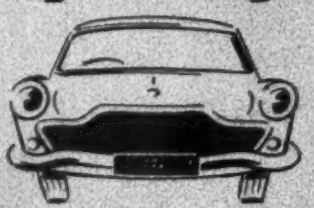

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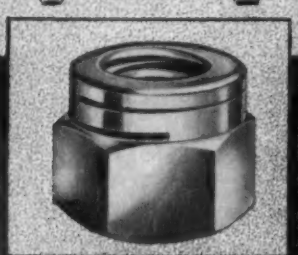

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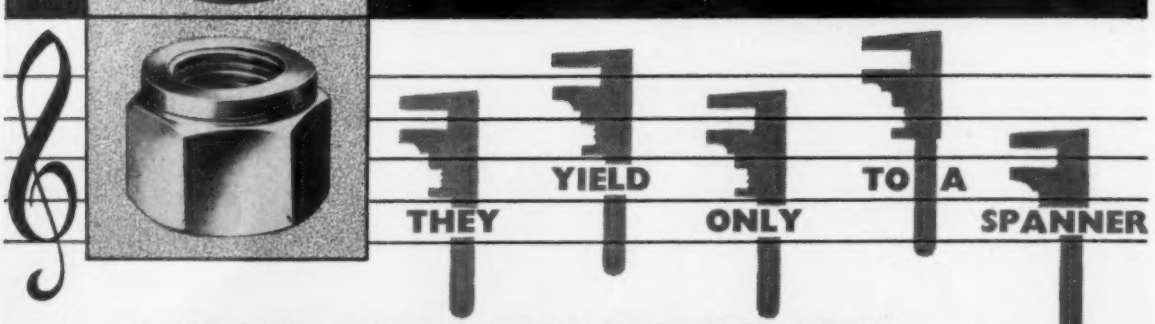

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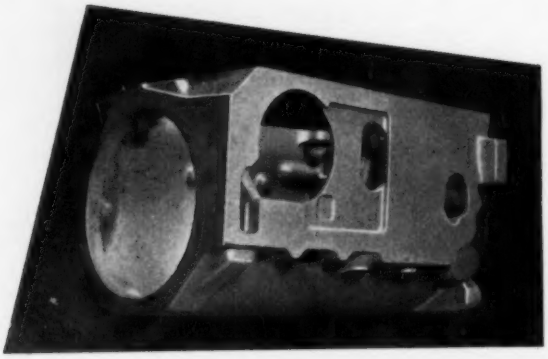

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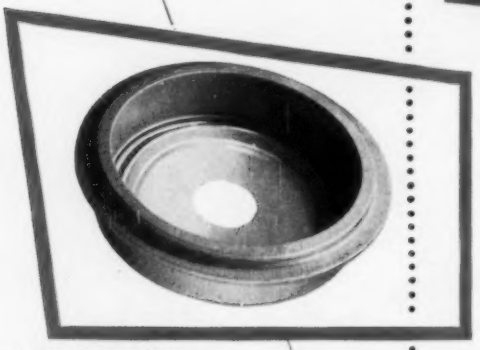

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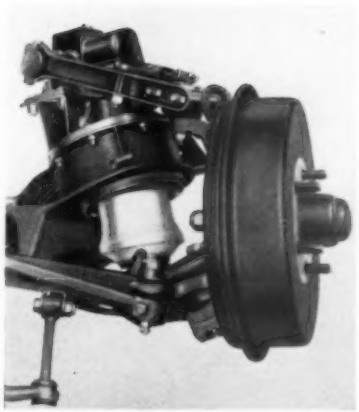

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Air Suspension Damping

WITH the introduction of air suspension, three major problems have arisen so far as damping is concerned. One is fundamental, in that the air spring rate is varied as between the laden and unladen conditions so the damping characteristics should be regulated to suit. The other two arise because of the almost complete lack of friction damping in the air springs. As a result of this, the damping has to be effected entirely by the hydraulic units which are, therefore, more heavily loaded than they are when used with conventional, semi-elliptic springs. Also, because of the absence of a background of shock loads and high frequency vibrations transmitted through the springs, the loads that are passed through the dampers are very noticeable to the occupants of the vehicle.

An analogous situation arose when flexible mountings were introduced for engines. This greatly reduced the transmission of engine vibrations and noise to the body, and the other noises and vibrations, notably those excited by the road surface, became much more apparent.

It is obvious that original thought is needed on the subject of damper design for air suspension. The first question that arises is whether pneumatic damping, by restriction of the air flow between the spring and its surge tank, is practicable. It would appear that this form of damping might be used to reduce the load on the hydraulic units. However, by itself, it is not adequate to meet all requirements because, when the suspension deflects rapidly, restriction of the flow between the spring and the surge tank has much the same effect as cutting out the surge tank altogether: in other words, it increases the spring rate.

A noteworthy suggestion was made recently by V. E. Gough, of the Dunlop Rubber Co. Ltd., in the discussion on a paper entitled "Air Suspension for Road Vehicles," read before the Automobile Division of the Institution of Mechanical Engineers. It was to the effect that pneumatic damping might be used for the relatively low frequency ride vibrations, while dynamic absorbers, such as are used on the Citroën 2CV, might be installed to cater for the relatively high frequency vibrations due to wheel hop. This arrangement is worthy of serious investigation in relation to small cars, but it would present some difficult problems with regard to applications where the weights of the unsprung masses are high.

It seems likely that, at least for many applications, hydraulic damping will continue to be employed, but that the design of dampers will be radically changed. One suggestion that has been made is that the damper design should be such that small movements of, for example, about $\pm\frac{1}{4}$ in from the static or mean position, should be entirely undamped, so that high frequency vibration of small amplitude would not be transmitted to the sprung mass. However, this hardly seems to be practicable since, in the absence of damping in these circumstances, there would be a tendency for the amplitude of the vibrations to build up until damping came into effect. Also, the loss of damping over this portion would have to be made good over the remainder of the stroke.

Adjustable hydraulic dampers have been available for some time, and it may well be that the solution to the problem with regard to air suspension is to develop an automatic adjustment device. For example, control could be effected by means of a capsule subject to the air pressure in the spring. The capsule might be filled with hydraulic fluid that would be displaced, in proportion to the air pressure, to actuate the adjuster. A simple adjuster might be developed by employing a taper-ended screw to restrict the flow through an orifice in the damper. The screw could have a multi-start or coarse pitch thread to limit the angle of rotational movement required to effect adjustment. An advantage of the employment of a screw thread is that it would provide for positive axial location, which cannot be readily obtained when a taper-ended plunger is simply moved axially.

A serious disadvantage of automatic adjustment of the damping is, of course, that it further complicates a system of suspension that already is so complex that for many applications it is barely acceptable. The alternative, of manual adjustment, is not attractive. For private cars, the control would have to be on the dash, and this would involve the use of cables or other forms of linkage that periodically would require lubrication or other attention. Although an external, manually operated control might be acceptable for certain types of commercial vehicle, it would appear far from ideal, since there would always be the tendency for some drivers not to take the trouble to use it. Improper adjustment of the damping might offset some of the advantages of air suspension; for example, the ride would be inferior, the shock loading on the vehicle would be increased, and the life of the structure correspondingly reduced.

The demand for a suspension system that has the advantages that can only be obtained with automatic height adjustment is such that it must be satisfied. Since air suspension has received so much publicity and is already in use, all the associated problems undoubtedly will be solved. In the past, motor manufacturers have always overcome difficulties with regard to high cost, and there is little doubt that they will do so again in this connection.

DUNLOP AIR SUSPENSION

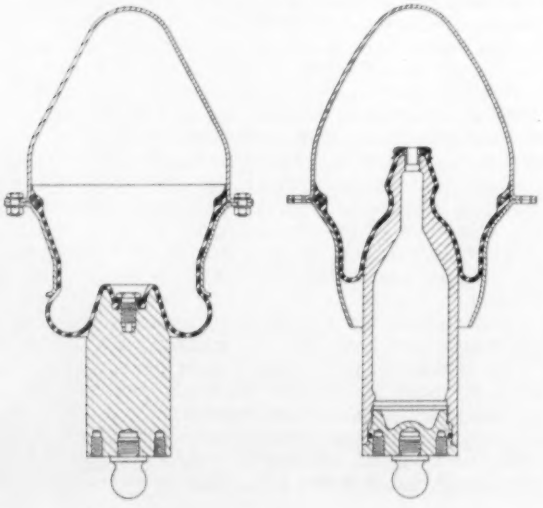
Comments on the Progress of the Design and Development Work So Far Undertaken in Connection with the Pneuride Systems

IN this country, a considerable amount of development work has been going on behind the scenes in respect of air suspension systems, both for cars and for commercial vehicles. The Dunlop Rubber Co. Ltd., of Foleshill, Coventry, have been developing their Pneuride systems, and are among those that have made great advances. From the outset, the aim of the company has been at giving the vehicle manufacturing industry a positive lead, by preparing the initial designs, in addition to doing the subsequent development work on the systems. This has involved the setting up of a relatively large organization within the firm to deal with all the aspects of this suspension work.

All the systems so far developed for cars and commercial vehicles have certain features in common. Rubber containers of either the diaphragm type or the single-, double- or treble-convolution bellows type form the air springs. Hydraulically-damped control valves maintain the vehicle height and attitude constant, irrespective of load carried.

The advantages of air suspension are already well known. Perhaps the most important is that the available space for wheel deflection is put to optimum use by virtue of the automatic height control device. Because the vehicle attitude is also constant, changes in headlamp alignment, owing to varying loads, are avoided. The controlled height of the loading platform is also a useful feature in certain applications. Another important advantage is that between the laden and unladen conditions, the spring rate varies much less than that of conventional steel springs. This reduces the dynamic loading, particularly in the unladen or lightly laden conditions, on the tyres, wheels and chassis; accordingly, it will undoubtedly give a marked increase in service life, and will also simplify design problems in respect of other aspects of vehicle construction. The improved standard of ride comfort and noise reduction obtained with air springs reduces both driver and passenger fatigue.

Two types of rolling diaphragm air springs now under development by the Dunlop Rubber Co. Ltd. That on the right is of the closed skirt design, while that on the left has a shortened and more open skirt



Since the levelling valves are hydraulically damped, the air requirements for the suspension are small. It follows that the Pneuride suspension can be applied to vehicles fitted with even the smallest of compressors for their brake systems. The arrangement of the suspension is such that a leak or any form of failure in the suspension system cannot affect braking efficiency.

Bellows type springs

Two general categories of air springs are employed by Dunlop. One is the bellows type and the other the rolling diaphragm type. All the varieties of spring within these two categories made by this manufacturer are of synthetic rubber reinforced with nylon cord. The techniques of producing this type of component have been well tried and proved in the manufacture of tyres and other equipment used in vehicle, aircraft and other industries Both bench and road tests have established that, under normal working conditions, springs of this type of construction should last throughout the life of the vehicle without replacement.

The bellows type of air spring is probably the least expensive, but it has certain limitations with regard to the length of stroke obtainable. For bellows up to 9 in diameter, the maximum stroke obtainable is 6 in, and for components of over 9 in diameter, the maximum stroke is 9 in. The decision as to whether to use single-, double- or treble-convolution type bellows is based on the stroke required. For a given volume of spring, the rate of change of effective plan-area with deflection is less with the treble- than with the double-convolution type, and the difference is, of course, even greater between the single- and treble-convolution types. It follows that the spring rate can be reduced by increasing the number of convolutions. The practical limit to the number of convolutions that can be used is, of course, determined by limitations with regard to the stability of the bellows.

Two detail features of the Dunlop bellows type air spring are of interest. One is the form of separator ring used between the convolutions. It was found that with a circular section separator ring there was a tendency for the cheeks of the convolutions to chafe against one another. This was avoided by the employment of rings of elongated, tear-drop shaped section, as shown in the accompanying illustration. At first, a symmetrical section was employed, but later it was found that the other section illustrated was better, because it is easier to produce. The first operation in the production of the latter type of ring is to press the form of the lower portion of the section, including the joggle, while at the same time turning up a flange round the inner periphery of the ring. In the second operation, this flange is rolled over until its edge seats in the joggle on the lower portion.

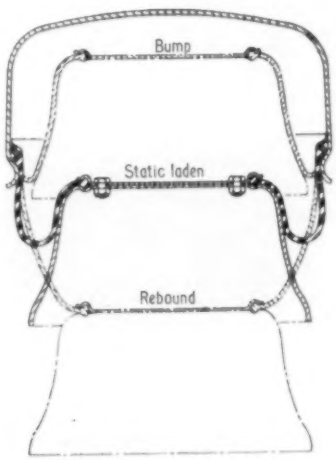
The other detail feature of interest is the sealing arrangements. At each end of the bellows, a bead is formed round the aperture. This bead seats tightly round a spigot formed

by the dished centre of a circular plate. Sealing is obtained by the employment of a lipped steel ring round the bead. The inner periphery of this ring fits into a groove in the outer periphery of the bead, and the outer periphery of the ring seats on the circular plate. The air pressure forces the end of the bellows against this ring, the inner periphery of which forces the bead against the tapered spigot on the end plate, thus forming the seal.

An important feature of this arrangement is that it does not require bolts or any other form of fixing to make it airtight. In fact, the manufacturers state that its air-tightness is even better than that obtained with sealing rings that are bolted down. Moreover, when bolts are used, it is not always easy to accommodate the heads and nuts in such a way that they do not chafe or damage the rubber in any way.

Rolling diaphragm type springs

These springs are attractive for two main reasons. One is that relatively large deflections can be obtained with them and the other is that they can generally be used without an auxiliary air tank or, if an auxiliary tank is required, it can be



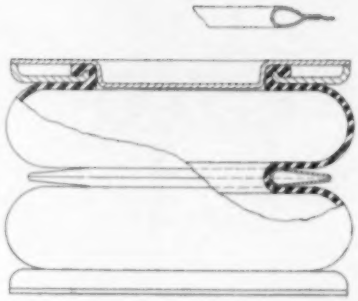
This rolling diaphragm type air spring has been developed for application to medium and heavy commercial vehicles. It is easy to produce, since all the principal metal components are pressings

incorporated in the piston that pushes the diaphragm in and out of the cylinder. Other advantages of this type of spring are that it is completely stable over the whole length of movement and its load deflection characteristics can be easily regulated, at the design stage, to suit the requirements of the vehicle. Generally, the aim is at giving a low rate over the normal riding range of deflection, while giving a rapid increase in the rate at the rebound and bump ends of the stroke.

Two of the different forms of rolling diaphragm type air springs that are undergoing development by Dunlop are shown in accompanying illustrations. One is of the open-skirt type, with which the build-up in spring rate at the rebound end of the stroke is obtained largely by the rapid rate of increase of enclosed volume as the piston is withdrawn from the lower end of the cylinder. The decrease in effective area of the piston at this end of the stroke also helps to reduce the rate. A closed-skirt type layout is shown in the other illustration. In this, the fall-off in rate is obtained largely by the reduction in effective area of the piston and diaphragm as the latter rolls down the inward taper at the lower end of the skirt. The increase in the enclosed volume also helps, but its effect is of secondary importance with this type of layout.

With both types of spring, sealing round the outer periphery of the diaphragm is effected by the action of the air pressure forcing it against the cylinder and skirt. A bead

A bellows type air spring with end seals that do not require clamping bolts. The scrap view above is of the latest design of separator ring, which is easier to manufacture than that shown round the centre of the air spring below



round the outer periphery seats in the angle at the flanged junction between the lower end of the cylinder and upper end of the skirt, where these two components are bolted together. In both cases, the centre of the diaphragm is attached to the upper end of the piston, but in one it is secured by a set bolt and circular section steel ring, and in the other by a pierced, pressed steel thimble, fitted over the bead round the central hole in the diaphragm.

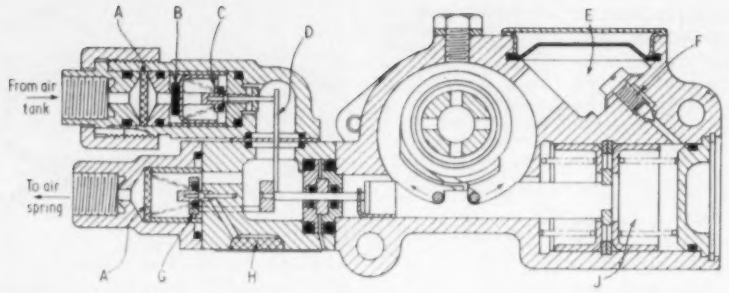
When the set bolt and ring are used as the securing method, the ring is pulled down on to the bead, which it retains on its seat in the end of the piston. The pierced thimble is employed when an auxiliary reservoir is incorporated in the piston. In these circumstances, a plug incorporating the damping orifice is carried in the hole in which the retaining bolt would be screwed if the other method of sealing were employed. As can be seen from the illustration, the rubber fits over two opposed tapers at the upper end of the piston, and the seal is effected partly by virtue of the fact that the rubber is stretched over these tapers and partly by the air pressure tending to hold it down on them. The amount of stretch is small so that the resultant tensile stress in the rubber is smaller than the compressive stress due to the air pressure. This ensures long service life.

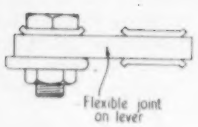
Pneuride levelling valve

As in most of the air suspension systems introduced so far, the levelling valve is mounted on the chassis and its operating lever is linked to the suspension. When the vehicle is being either loaded or unloaded, and the chassis falls or rises relative to the suspension, the consequent movement of the lever causes air to be admitted or exhausted, according to whether the chassis has to be raised or lowered to re-adjust the static height. A noteworthy feature of the Dunlop system is that a flexible rubber link is used to connect the actuating lever to the rod attached to the suspension. The function of this flexible link is to isolate the actuating lever from the small amplitude, high frequency oscillations of the unsprung mass, and thus to reduce the wear and tear on the damper and other components of the valve.

A hydraulic damping, or delay, device is incorporated in the unit so that the valves are not operated by dynamic movements of the axle as the vehicle rides over rough ground. This not only economizes in air consumption, but also obviates oscillations and other undesirable effects that may tend to build up when undamped valves are employed. When the load carried by the vehicle is increased or decreased, the levelling valve comes into operation after a predetermined delay period and continues to operate until the normal static height has been regained.

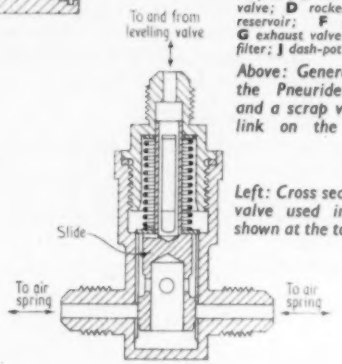
This delay period can be readily adjusted to suit the requirements of individual types of vehicle. With certain classes of goods and passenger-carrying vehicles, it has been found that a delay period of about 8 sec is desirable. This is adequate to ensure that the levelling system is not brought into operation by the roll of the vehicle when it is travelling round long bends. If the valve were to operate in these circumstances, the vehicle would come out of the bend with a





A *filter;* **B** *non-return valve;* **C** *inlet valve;* **D** *rocker lever;* **E** *hydraulic reservoir;* **F** *adjustable restrictor;* **G** *exhaust valve;* **H** *exhaust port and filter;* **J** *dash-pot delay system*

Above: General arrangement of the Pneuride levelling valve, and a scrap view of the flexible link on the actuating lever



Left: Cross section of the isolator valve used in the installation shown at the top of the next page

Right: The Dunlop Pneuride automatic levelling valve and the isolator valve

list to one side; this would be particularly dangerous on an S-bend, since it might cause the vehicle to be overturned while entering the second curve of the bend.

Two, three or four levelling valves may be installed on each vehicle, according to individual requirements. Generally it is advisable to employ two at the rear, where the load changes are greatest, and one at the front. The levelling valve at the front is connected to an isolator valve, which forms a T-junction in the pipeline to the two air springs. This isolator valve permits the air to flow to and from the two springs simultaneously but prevents transfer of air between the springs when, for example, the vehicle is cornering: in other words, it avoids loss of roll stiffness.

The height regulator valve comprises two assemblies bolted together. One houses the actuating mechanism and the components of the hydraulic dash-pot delay system, while the other incorporates the components of the pneumatic valve system. All the reciprocating components, such as the pneumatic valves and hydraulic dash-pot are mounted with their axes horizontal, so that they are unaffected by vertical accelerations as the vehicle traverses rough terrain. The layout and method of operation of this unit is clear from the illustration of its cross section; therefore, a few comments on the more interesting features are all that are necessary in the description that follows.

A cast iron housing is employed for the hydraulic section of the assembly, but the pistons of the dash-pot are of aluminium alloy. The reason for this choice of materials is as follows. As the ambient temperature falls, the clearance between the pistons and the bore in which they operate increases, while the viscosity of the fluid increases; these two changes tend to cancel out so far as their effect on the time of operation of the dash-pot is concerned. It has been found that silicone fluid, because of its relatively low rate of change of viscosity with temperature, is most suitable for use in this dash-pot.

The spindle of the actuating lever is horizontal and it is mounted with its axis arranged transversely relative to the piston rod of the dash-pot, which is below it. A coil type torsion spring forms the connection between the actuating spindle and the piston rod. Thus, as the actuating lever is moved up or down from the mean position, it applies a load through the torsion spring to the piston rod, the rate of movement of which is regulated by the leakage of fluid through the transfer port, and also past the dash-pot pistons. A restrictor screw is fitted in the transfer port, so that the rate of fluid flow can be adjusted. In this way, the period of delay between the movement of the actuating lever and the operation of the pneumatic valves can be regulated.

There are two pistons. They are formed by cupped pressings fitted one each side of a circular plate mounted on one end of the piston rod. A coil type compression spring is interposed between each of these pistons and the adjacent end of the cylinder. Axial movement of the rod in either direction from the mean position pushes one or other of the pistons along the bore, against the compression in the return spring. The other piston is retained in the mean position by a double circlip in a groove mid-way between the ends of the bore of the cylinder. The advantages of this arrangement are that the components of the piston are simple to manufacture, and fine limits of concentricity between the rod, piston and bore are unnecessary.

The whole of the damper casing is completely filled with fluid. Slight variations in volume of the fluid and its container, owing to thermal changes, are accommodated by flexure of a rubber diaphragm fitted over the chamber that houses the adjustment screw of the restrictor. This diaphragm is retained by a pressed-in cap. There is an air cell in the cap above the diaphragm, while below it, the fluid is entirely free from air.

A valve actuating rod is fitted to the other end of the piston rod. It is passed through a seal assembly that separates the hydraulic and pneumatic sections. All the seals, in this assembly and at other stations in the valve, are of simple circular section and are of rubber. There are two of these sealing rings round the actuating rod, and the space between them is vented to atmosphere so that if any air leaks past the seal nearest to the pneumatic valves it does not go through the other seal into the hydraulic section of the unit.

The other end of the actuating rod is connected to a rocker lever that actuates the air inlet valve and also to a push rod that actuates the exhaust valve. Movement of the damper piston and the actuating rod in one direction causes the rocker lever to pivot about its centre and open the inlet valve to admit air from the tank. When the piston moves in the other direction, the rocker lever returns. This allows the inlet valve to seat again, and then the push rod lifts the

exhaust valve off its seat, allowing air to flow from the spring to atmosphere. A filter is fitted in the vent to atmosphere to prevent the entry of foreign matter when the exhaust valve is closed. There are two more filters, one in the inlet from the tank and the other in the outlet to the spring.

Another feature of the pneumatic valve assembly is the incorporation of a non-return valve in the inlet from the tank. This ensures that, should the pressure in the tank be less than that in the springs, the air cannot flow in the opposite direction to that intended. In other words, it is a safeguard to prevent complete failure of the air springs, should there be a breakdown in the pneumatic supply system.

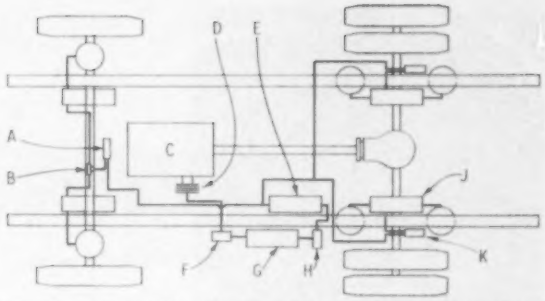
Isolator valve

If a levelling valve were to be applied to each wheel, it would be possible for the springs to be supported mainly by two diagonally opposite air springs. This would lead to instability and severe stressing of the vehicle frame. Therefore, as has already been stated, only two or three levelling valves, rather than four, are generally employed. Where two air springs are fed from one valve, it is desirable to isolate one spring from the other, to prevent loss of roll stiffness owing to the interchange of air between them. To this end the Pneuride isolator valve has been developed. Its design is such that it allows air to be admitted or exhausted from each spring through the levelling valve, but permits only a predetermined leakage of air from one spring to the other.

As can be seen from the accompanying illustration, the valve is of the slider type. When the inlet of the levelling valve opens, and the pressure in the pipeline from the levelling valve to the isolator valve is increased, the slide is moved downwards until the two ports to the air springs are uncovered. This allows the air to pass from the levelling valve, through the hollow stem of the slide, into the plunger chamber and thence out through the two ports to the springs. When the exhaust port in the levelling valve is opened, the pressure in the pipeline between the two valves collapses, and the pressure from the air springs moves the slide in the opposite direction. This again uncovers the ports, so that the air can flow through the counterbore in the centre of the slide, and thence radially outwards and back along the same passages through which the air enters when it is being fed under pressure into the springs. A small leakage of air from one spring to the other is permitted so that the mean pressure in both is equalized.

Practical applications

One of the accompanying illustrations shows a typical layout of the components of the Pneuride air suspension system on a chassis, with a beam axle both at the front and rear. Air for the engine-driven compressor is taken through either a separate filter or the engine air intake filter. From the compressor, the air passes to a conventional unloader,



A levelling valve; B isolator valve; C engine; D compressor; E suspension air reservoir; F unloader valve; G brake air reservoir; H charging valve; J auxiliary air tank; K levelling valve

Diagram showing a typical layout of an air suspension system

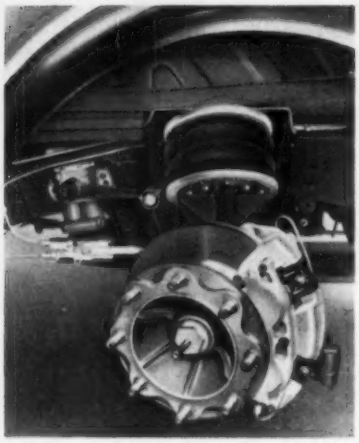
valve, which is incorporated to relieve the load on the compressor when the reservoirs are fully charged. It then passes first into the brake reservoir; subsequently, when the pressure of the air in this reservoir reaches a certain value, the charging valve at the other end opens and allows air to pass into the suspension reservoir. Thus, in the event of a severe leak in the suspension system, there will always remain enough air in the other reservoir to operate the brakes.

From the suspension reservoir, pipelines are taken to the three levelling valves, one for the front suspension and one on each side over the rear axle. The single levelling valve at the front is connected by a pipe to an isolator valve, whence the air passes to the auxiliary reservoir and air spring on each side. At the rear, there are four air springs, two on each side. They are mounted in pairs on two yokes, one at each end of the axle, so the outlet from the levelling valve on each side goes directly to the adjacent auxiliary reservoir and thence to the two air springs.

In the system that this illustration depicts, each auxiliary tank at the rear is of 150 in³ volume and serves two springs of 350-400 in³ volume. The total deflection is ± 3 in and the natural frequency in the laden condition is 115 c/min. Each auxiliary tank at the front is of 200 in³ volume and serves a 350-400 in³ spring. The deflection again is ± 3 in. but the natural frequency is 105 c/min, which gives a frequency of 95 c/min at the wheel. This fairly high natural frequency has been chosen, with a view to obtaining a satisfactory compromise between ride quality and roll stiffness.

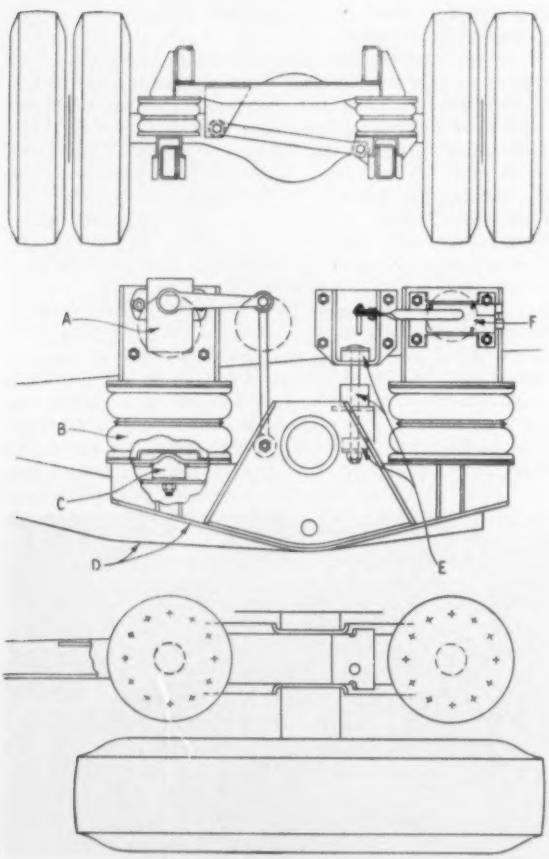
A series of line and half-tone illustrations shows in rather more detail the arrangement of the actual suspension units. At the front, since it was not practicable to fit a Panhard rod in this particular installation, a divided axle layout has been employed. This has given good results so far as roll stiffness is concerned and, in the development work so far carried out, has not yet shown any disadvantage with regard to tyre wear. It is possible that the automatic levelling of the suspension may partly account for the unexpectedly low rate of tyre

This illustration of the commercial vehicle rear axle suspension system, as viewed from behind, shows how lateral location is effected by a Panhard rod. The rearmost rubber stop interposed between the trailing link and the spring seating yoke on each side can also be seen



Above: Front suspension arrangement, as applied to the commercial vehicle mentioned in this article. An incidental feature of interest is the installation of the Dunlop disc brake with ventilated pads which, because of their accessibility, are easy to replace in service

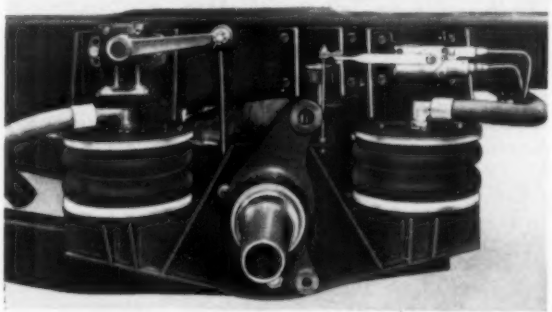
Below: Three views of the rear suspension used in conjunction with the front suspension system illustrated above. An interesting feature of this arrangement is the pivot mounting of the spring carrier yoke on the trailing arm, and the interposition of rubber stops between the arm and the spring seats to regulate the roll stiffness of the suspension system



wear. The reduction of variation in natural frequency as between the laden and unladen conditions also undoubtedly improves tyre wear.

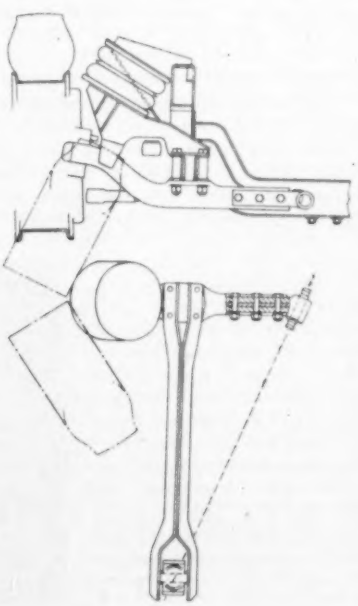
At each side, the axle is located by a drag link pivoted in a bracket mounted further back on the frame side member. This link also takes brake torque. The double-convolution air bellows type of spring is mounted, in much the same way as a coil spring, between two seating pans, one on the axle and the other on the frame side member.

At the rear, the axle is located by two trailing links, one on each side, and a Panhard rod. The forward end of each trailing link is pivoted in a bracket mounted under the frame side member, and the rear end is pivoted at a point immediately below the axle, between the two downwardly-turned flanges of the inverted U-section yoke that carries the two air springs. Rubber stops are precompressed between each end of the yoke and the trailing link. The function of these stops is to control the rate of torsional deflection of the trailing links relative to the axle; in other words, they

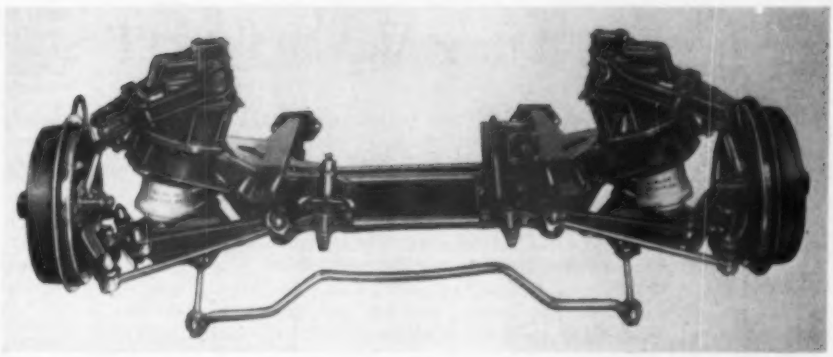


Above: The photograph from which this illustration was prepared is of the rear suspension installation shown in the line diagrams on the left

Below: Two views of the front suspension system illustrated at the head of the previous column. The divided axle layout was adopted to clear the base of the engine, and development work undertaken so far has not indicated any difficulties with regard to rate of tyre wear



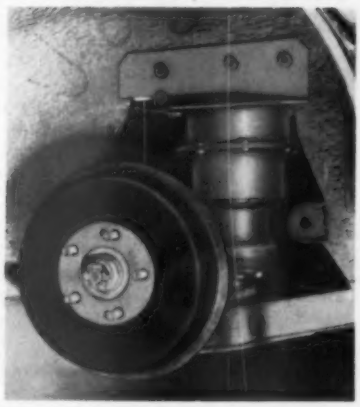
Front suspension installation for a private car currently in production. The whole of the suspension and steering assembly, including the rolling diaphragm type springs, is carried on the front cross member



regulate the roll stiffness of the body on the rear suspension.

The double-convolution bellows type springs are interposed between the ends of the yokes and the brackets mounted under the frame side member. One of these latter brackets also carries a lever type shock absorber, which is connected by a drop link to the axle assembly. The other bracket carries the automatic levelling valve, which also is connected by a drop link to the axle assembly. As has been mentioned before, a short rubber connection is interposed between the end of the arm of the levelling valve and the drop link. The bump and rebound stops are formed by a tie rod passed through one hole in a bracket on the frame and another in the yoke assembly, immediately below. Three circular rubber stops are threaded on to the tie rod, one between each end of the rod and the adjacent bracket, to take the rebound loads, and the third is interposed between the brackets, to cushion the bump loads.

Another illustration shows a suspension arrangement for a trailer with a beam axle at the front and rear. Both axles are located by trailing links and a Panhard rod. Roll stiffness is obtained at the front in much the same way as on the rear axle of the chassis previously described, but in this particular instance, screw adjusters are provided to regulate the pre-compression in the rubbers interposed between the trailing links and the spring seating bracket. At the rear, the trailing links are rigidly clamped to the axle, which is of square section and acts as an anti-roll bar. On semi-trailers, the provision of adequate roll stiffness on the rear axle is of considerable importance, because there is no roll stiffness at the front. Every type of trailer requires an efficient seal to prevent the escape of air from the system when it is disconnected from the tractor.



The rear suspension used in conjunction with the front end assembly illustrated above. A trailing link is employed, together with a rolling diaphragm type spring on each side, and lateral location is effected by a Panhard rod

Private cars

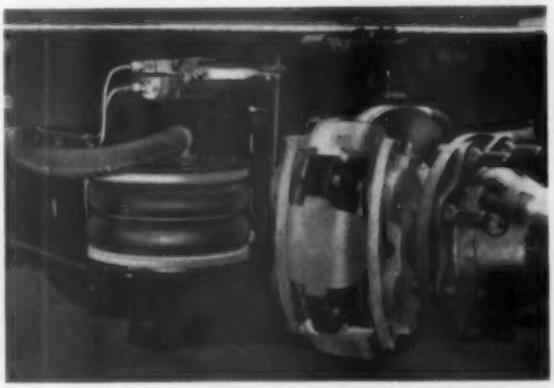
Some of the half-tone illustrations show a rolling diaphragm type air spring system applied to a well known private car chassis. At the front, the air springs have simply been substituted for the coil springs in the double transverse wishbone link type layout. Separate auxiliary tanks are not necessary, since there is adequate space in the pistons for the extra air capacity required. At the rear, a trailing link has been substituted for the leaf spring and an air spring interposed between it and the under frame of the vehicle. Lateral location is effected by a Panhard rod.

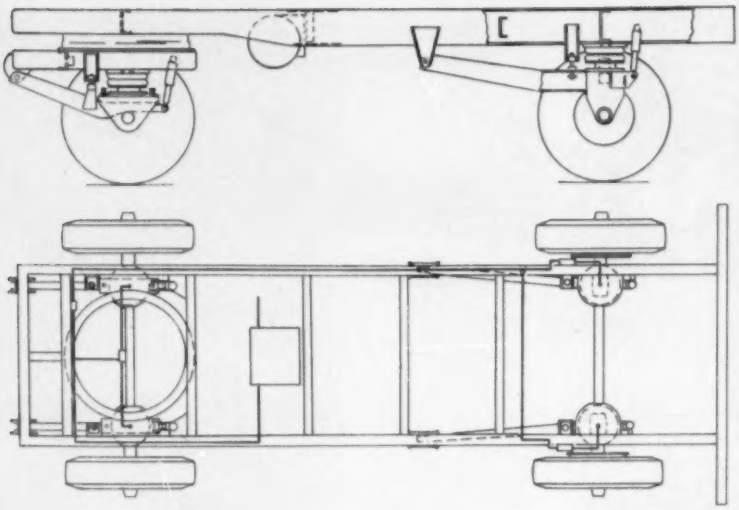
For development purposes, an air bottle is employed, instead of a compressor. It is charged to a pressure of 2,500 lb/in^2 and lasts for about seven or eight days before it requires recharging. However, it is likely that a small compressor would be fitted to the engine on a production model.

Dunlop have also been studying closed circuit systems, but a great deal of work remains to be done before this type of arrangement can be proved satisfactory. The advantages of this system are that troubles due to condensation in the air are less likely to occur, and although filters are still needed, they can be much smaller than with the open circuit types of air suspension. The air consumption is limited to that needed to compensate for leakages and is only about 10 per cent of that of an equivalent open system. Therefore, the air compressor can be much smaller. The main disadvantages of a closed circuit arrangement are that an additional reservoir is needed and the piping is slightly more complicated.

Although air suspension is certainly coming for commercial vehicles, most manufacturers are still in some doubt as to whether the demand for it on private cars is great enough to justify the additional cost involved. Some of the American car manufacturers are currently offering air suspension

A view of the trailing end of the rear suspension illustrated opposite



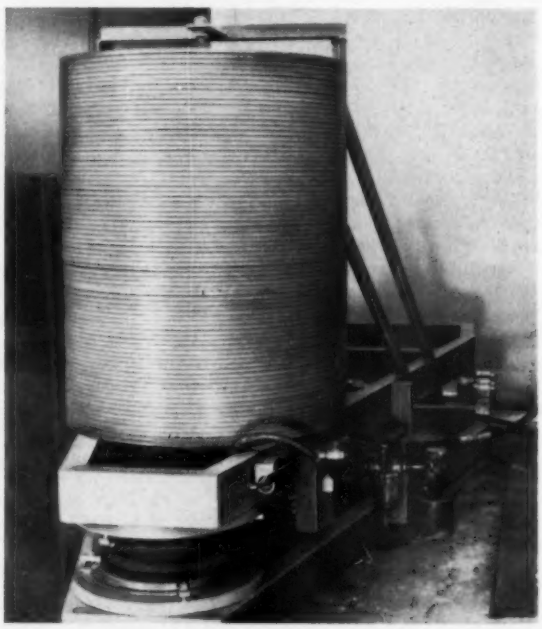


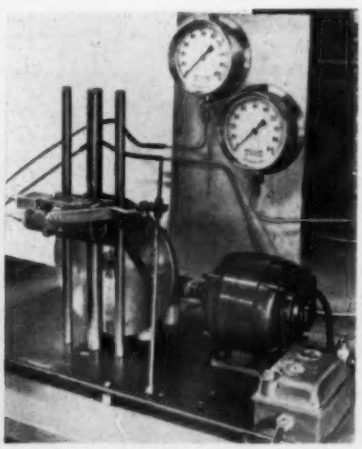
Left: Suspension system for a trailer with a beam axle at the front and rear. Both axles are located transversely by Panhard rods. Roll stiffness at the front is regulated by means of rubber stops interposed between the spring seating yoke and the trailing link on each side, but at the rear, the square section axle beam performs the function of an anti-roll bar

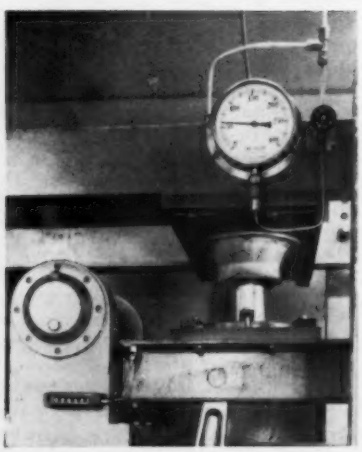
as an optional extra at a price approximately equivalent to £45. In Britain, purchase tax would, of course, have to be added to this figure. It would appear that air suspension is better suited to the small European cars than to the much larger American ones. This is because the ratio of laden to unladen weight is much greater with the European vehicles; also, because of the smaller dimensions of our cars, the space available for wheel deflection is restricted and therefore, needs to be used to the best possible advantage, which can be done, of course, by the employment of an automatic levelling device.

It would appear that the extra cost of the air suspension, by comparison with more conventional systems, can be largely attributed to the employment of an air compressor, levelling valves, air reservoir and pipelines, the actual springs themselves being probably equivalent, so far as cost is concerned, to the steel spring arrangements currently used. Some of the additional cost could undoubtedly be offset by using compressed air for other purposes, such as actuating the windscreen wipers, providing power-assisted steering, seat and window movement and, ultimately, brake operation. Most of these amenities are likely to appear in any case on the larger and more expensive cars, so it seems that air suspension also will be first introduced on vehicles of this type. It is possible that further developments and improvements in design and production will lead eventually to the widespread adoption of air suspension for private cars of all sizes.

Illustrated below are four machines used in the department of the Dunlop organization devoted to the development of air suspension. The large machine is used for the endurance testing of bellows; the weighted end bounces continuously at resonance frequency on the bellows spring. Of the other three machines, that on the left is for checking the delay period of levelling valves; the centre one is for fatigue testing levelling valves, by moving them up and down in much the same way as they would be moved in vehicle installations; and the machine on the right is for endurance testing rolling diaphragm-type springs







Expander Type Oil-Control Rings

An Account of the Developments Leading to the Introduction of the Wellworthy Duaflex Oil-Control Ring, and Some Comments on the Design Problems

An expander type ring is, of course, one that depends either partly or wholly on an expander spring for the regulation of the radial pressure it exerts on the bore in which it operates. Few people realize that rings of this type were introduced even before the beginning of this century: for example, a patent in connection with an expander type ring for steam engines was filed in 1897. When motor transport became widely used, the need for an oil-control ring for fitting at an intermediate stage between the manufacture and rebore of engines became apparent. This need arose because the ordinary slotted oil-control ring, which was, and still is, completely effective in normal conditions, was proving unsuccessful in satisfying the requirements of worn bores and dealing with the additional flow of lubricant flung from worn bearings.

To meet the demand for a special ring that would operate satisfactorily under these conditions, Wellworthy Ltd. made an agreement with Simplex Products, of America, for the production of the Simplex ring in the factory at Lymington, Hampshire. This ring is claimed to be one of the first, with an independent radial expander ring, for application to internal combustion engines; it is also said to have been the first designed to exert a side-pressure in the groove. As can be seen from the accompanying illustration, two rows of slots are machined round the periphery of the ring: all extend radially through the ring and are arranged so that the ends of the slots in one row are in line with the centres of those in the other row. By virtue of this arrangement, the ring can be compressed axially and it is, in fact, assembled on to the piston with a 0·010 in interference fit between it and the sides of the groove. This interference fit ensures that the ring seals against the sides of the groove under all conditions of operation, and therefore there is no possibility that oil pumping will occur. The radial pressure exerted by the expander spring is correspondingly high to keep the ring always in contact with the cylinder bore: in fact, the Simplex ring is able to conform to a surprising degree of taper and ovality in the bore.

For many years, this ring was the only one of its type available in Great Britain, although a number of others were appearing in the United States of America. Production of Simplex rings in the Wellworthy factory reached a peak during the Second World War, when they were adopted as a routine replacement for the standard rings on British Army transport. After the war, they continued to be made, but were gradually supplanted by rings of the laminated steel rail type. The advantages of this later type, termed the Molium, or All-steel ring, are as follows. It is better able to conform to slight irregularities in the bore. Higher bearing pressures against the cylinder wall are obtained, and thus the ring was more effective at the relatively high piston speeds and on the thin oil films that were beginning to be encountered when it was first introduced. Also, the Molium ring does not suffer from the main drawback of the Simplex ring, which is the danger of breakage while it is being fitted.

Although the new ring was only partially successful, because it lacked the advantage of side-pressure, the experience gained in its production formed a sound basis for further advances. That further development on these lines would be worth while was amply demonstrated by the performance of the Molium ring, which proved that, contrary to common belief at that time, neither the steel rings nor the bores in which they operate are subject to excessive wear, provided the profile of the ring face in contact with the bore is carefully designed and controlled in production and that the steel is suitably hardened. In fact, Wellworthy state that well designed and manufactured rings of this type have been found to give less bore wear than that experienced with conventional, cast iron rings.

The Molium ring, which was in production for two or three years after the war, represented only an intermediate stage in the development of laminated types, and the manufacturers continued intensive research and development to produce something better. Tests pointed to the desirability of retaining the original feature that had proved so successful on the original Simplex ring, namely side-pressure. Many types were tested and discarded before the Duaflex ring was evolved and proved to be a success.

This was the first and, at the time of its introduction, the only steel ring to embody simultaneously the dual features of radial and side loading by means of crimped springs. The design is such that the side-pressure is positive yet light, so that there is no interference with the outward, or radial, pressure on the cylinder wall and yet there is no oil pumping between the ring and the sides of its groove. These results have been achieved largely by strict control of both materials and dimensions.

Each Duaflex ring assembly comprises two, three or four side rails, which are made to bear positively but lightly against the sides of the groove by a single crimped spring sandwiched between them, as shown in the accompanying illustration; another crimped spring bears against the inner periphery of the assembly, to apply the radial pressure. The side rails are $0{\cdot}030 \pm 0{\cdot}0003$ in thick, and their gaps are a minimum of 0·012 in for rings of up to about $2\frac{1}{2}$ in diameter and 0·018 in for larger ones. Their faces that bear against the cylinder bore are rounded section. Thus, they have no sharp corners or cutting edges to cause bore wear, while at the same time the area of contact is small and the pressure is, therefore, high enough for the oil-control function to be performed efficiently.

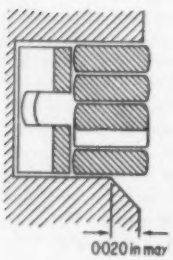
The rails and the side-pressure springs are made of D.T.D. 239A steel, hardened to 49-52 Rockwell C. It is, of course, a well established fact that hardened steel does not cause undue wear, whereas the use of soft steel gives rise to excessive rates of wear on both the bore and the rings. The mechanism of the wear process of soft steel on the lubricated surface of a cast iron cylinder has not yet been explained entirely satisfactorily. Recently, the rate of wear has been improved even further by chromium plating the outer rounded face of each of the side rails.

A 1 per cent carbon steel, containing 0·15 per cent of chromium, to improve its fatigue resistance, is employed for the radial pressure spring. The quality of the strip steel employed is of supreme importance; the material used is made from Swedish ore, which, of course, is well known for its high quality. All the strip is bought in the polished state, so that all the rolling and drawing marks have been removed; this helps further to obviate the danger of premature failures due to fatigue. All materials are carefully checked on arrival at the factory; both ends of each roll of strip are tested for tensile strength and hardness, and analyses are made periodically as a second check on the quality of the steel employed.

The design of the crimped spring rings is, perhaps, one of the major factors affecting the success of the ring assembly as a whole. The side-pressure ring is, as has already been stated, the same thickness as the side rails. The overall dimensions measured vertically between the opposite peaks of the waves, or crimps, is controlled to within 0·003 in, while the tolerance on the thickness of the strip is only 0·0003 in. The side pressure exerted is not great: in fact, the assembly would be better described as a ring without side clearance, rather than one with side-pressure. The radial width of the ring has to be smaller than that of the rails, otherwise it will act as a spacer between the radial expander spring and the bore, and thus prevent the rails from bearing properly in the bore.

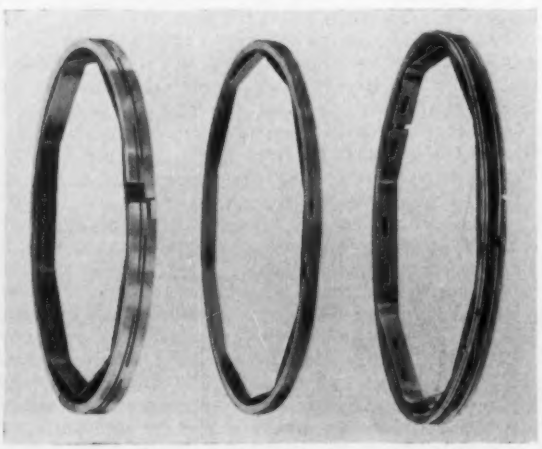
Since the depth of groove available is invariably restricted, there are rigid limitations with regard to the design of the radial expander ring. Slots are punched in the spring to allow the oil to flow freely away. Generally there are two slots on each flat and they are arranged in such a way that they do not weaken the spring at areas of maximum stress. These areas are at the peaks of the crimps and also midway between the peaks. Whenever these springs are modified, or new designs introduced, extensive fatigue tests are carried out before the new components are issued for service. The method of testing is to fit the rings to dummy pistons and to reciprocate the complete assembly in a tapered bore. This is, perhaps, a rather unconventional method of fatigue testing, but it has been found to be the best one for this particular application, since it is fairly closely analogous to the severest conditions under which the ring might have to operate.

From the foregoing description, it can be seen that the Duaflex ring is not just a trick ring to save a rebore, but is an example of precision engineering. In fact, it is currently fitted as initial equipment by some engine manufacturers, and has also been well established for several years for application to partly worn engines. In both worn and new engines, the ring is suitable for application when conditions are such that the oil control function is beyond the capacity of the more conventional type of ring.



Left: Cross section of the Duaflex ring, Patent No. 617,700. The oil relief chamfer should not be deeper than 0·020 in, otherwise there is inadequate support for the lower rail

Below: Three stages representing successive advances in the design of expander rings: left, the Simplex ring; centre, the Molium ring; and right, the Duaflex ring, which incorporates two crimped expander springs



In recent years, there has been a marked trend towards more exacting requirements with regard to oil control. This is because of the higher ratings and speeds of modern engines and also because of the general tendency to increase bore: stroke ratios. The larger diameter of the bores and the fact that they are closer to the crankshaft means that they receive greater quantities of oil than in earlier designs.

Under inertia loading at high speeds, conventional rings tend to leave the sides of the groove, and may even leave the bore. The tendency for the Duaflex ring to do this is greatly reduced by virtue of its light weight, positive side-pressure and relatively accurately controlled radial pressure. With a conventional ring, radial pressures are not so easily regulated, because they are dependent upon the radial depth of the ring and other factors that are difficult to control; also, the design of the ring has to be such that it can be readily sprung into position without risk of breakage. In a new engine, lower pressures are required than in one with worn bores. When this new ring is applied as initial equipment, it is customary for a considerable amount of development testing to be done to determine the optimum spring pressures.

Other factors that have led to the success of this ring are as follows. The rounded faces give high bearing pressures without danger of scraping or picking-up on the bores. Since there are two, three or four of these faces, one on each rail, there is less chance of the whole of the oil controlling surfaces in any one segment of the ring leaving the bore, since it is not likely that all the rails will leave simultaneously. The multi-point contact between the radial pressure spring and the rails helps to give uniform pressure round the bore; this is a particularly useful feature in worn engines. Also, each rail has a certain degree of inherent radial resilience and, therefore, to some extent, operates independently. The radial pressure spring helps to centralize the piston in the bore and thus obviates at least to some degree the ill effects of piston slap. It is thought that this latter effect is primarily responsible for the fact that the rates of bore wear experienced with these rings are lower than those obtained with conventional rings. The light weight of the ring assembly, as has already been mentioned, is an advantage so far as a reduction of inertia loading is concerned. Finally, the fact that the ring comprises a number of independent components gives a certain degree of both hydraulic and friction damping, and helps to prevent ring flutter or vibration.

Despite all attempts on the part of the motor industry to rationalize design, it has been found necessary to manufacture this ring in as many as 1,300 different sizes. The range of standard sizes is from 2 in to 7 in diameter. In addition to the standard sizes, the following oversize rings are supplied for use in worn and rebored engines: +0·020 in, +0·040 in and +0·060 in on the diameter.

When these rings are fitted, it is, of course, of vital importance to check the depth of the groove. For this reason, a fibre depth-gauge is packed in each carton of Duaflex rings and the correct depth of groove for each application is printed on the envelope. Up to 3½ in diameter bore, the tolerance on the groove depth is ±0·004 in, and for larger diameters, the tolerance is ±0·006 in. Grooves that are too shallow can, of course, be deepened according to the instructions supplied with the rings; those that are too deep can be packed with special perforated shims. When Duaflex rings are fitted to motor cycle pistons, the groove should be 0·005 in deeper than the dimensions quoted on the packet. The ring gaps do not need any alteration at all. It is important not to fit Duaflex rings into grooves with deep oil reliefs machined below them. Oil reliefs of more than 0·020 in depth leave too large an unsupported area below the bottom rail.

Continental Coachwork

Trends Towards Simplicity of Design and Low Bonnet Profiles

A STUDY of the products of the Continental coachbuilders who exhibited at the Geneva Show has revealed a number of positive trends. So far as front end styling is concerned, there is a tendency to extend bonnets forward of the lamps and, as in the previous two or three years, to adopt a falling profile towards the front to give a good range of visibility over the bonnet. The lengthening of the bonnet is reminiscent of the trend that was apparent during the 1920's. The object then, as now, was to give the impression that a large and powerful engine was installed under the bonnet.

The wing crown lines, of course, are generally higher than the bonnets, because of the need to provide adequate room for wheel deflection and also so that the width of the car can be readily judged by the driver. Many of the coachbuilders incorporate a pressed line along each wing crown, but in some instances this line is intended not so much to be distinctly visible itself, but rather is its function to reflect highlights that clearly define the profile.

Most of the radiator grille arrangements are of wide rectangular form, with the leading edge of the bonnet top overhanging. In some instances, the grille is extended right round the sides of the vehicle, to accentuate the horizontal features at the front end. Considerable success is being achieved in respect of the blending of traditional radiator grille forms into modern styles. A noteworthy example of this is the Ghia Suisse body on the Alfa Romeo chassis. Elliptical, rather than rectangular, front end arrangements are retained by some of the coachbuilders. One of the most attractive of these designs is the Beutler body on the Simca Aronde chassis. Where this type of layout is employed it is desirable that the styling of the sides and front and rear ends of the vehicle should be in conformity.

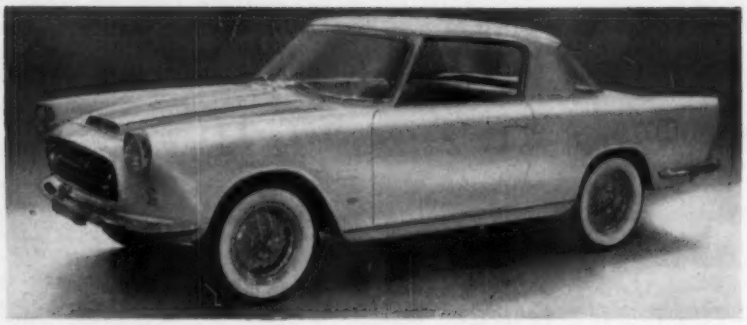
To obtain a falling bonnet line, practically all the coachbuilders incorporate on the bonnet lid an air intake duct to clear the highest parts of the engine. On a number of the latest bodies, this duct is divided longitudinally, either by pressing a channel section in it or simply by fitting a chromium plated finisher strip along the crown of the duct. Several manufacturers leave both the trailing edge and the leading edge of the duct open. This is done to provide through-ventilation under the bonnet to prevent fuel vapour lock under hot weather conditions.

On almost all the coachbuilt bodies, the waist-line and the sharply defined wing crowns sweep almost straight through from front to rear of the vehicle. A noteworthy exception to this is the Alfa Romeo body by Pinin Farina, which is obviously designed to appeal to the American market, where this type of line is popular. On most of this year's models finned rear wings are employed, but so far there has been little enthusiasm over the upswept fins currently employed on a number of the quantity-produced American cars. Again, one of the few exceptions is the Pinin Farina Cadillac, in which the extreme rear ends of the fins are slightly upswept. Rear end designs in general are simple and devoid of excessive chromium plated ornamentation. There is a trend towards pressing the skirt panels into a rectangular form to harmonize with the front end treatment.

So far as interior trimming arrangements are concerned, there is a tendency to use noise and heat insulation materials more extensively than hitherto for backing the trim. In some instances, foam-plastics sheeting is employed and in others glass fibre. Undoubtedly, the design of the trim on the doors of the more expensive vehicles will be simplified by the incorporation of power-actuated window raising mechanisms and seat shifting devices. Power actuation, of course, makes it possible to eliminate all handles except that required for opening the door. Presumably even this handle could be concealed or incorporated elsewhere.

Most of the new models have wrap-round windscreens, and at least 50 per cent have wrap-round rear lights, but few have such a large wrap-round as on the American cars. Presumably this is because the length of the European cars is so much less, but it also obviates difficulties with regard to screen wiping. A wide variety of rear quarter panel treatments is employed: as can be seen from the accompanying illustrations, the number of completely different designs is largely accounted for by the difficulty of making

This Vignale body on the Triumph TR3 chassis has a power-operated hood. Before the hood can be raised, the wrap-round glass of the rear light has to be removed, by undoing two knurled thumb screws; then, when the hood is up, the glass is replaced as it was before



The Allemano Fiat 1200 coupé has a forward-extended radiator air intake and a divided air intake duct on the bonnet lid. Both these styling features are widely employed on the latest Continental coachbuilt bodies

the lines of the wrap-round glazing frame harmonize with the general theme of the style of the vehicle.

Hardly any of the coachbuilders employ plain disc type wheels. The majority use a nave plate pressed to form an imitation spoke type wheel, and nearly all the remainder have wire wheels. Imitation spoke type nave plates are probably easier to clean and also seem to be more suitable, from the aesthetic point of view, for the smaller cars. Wire type wheels, however, tend to lighten the appearance of the larger cars.

The trend towards simplicity in styling is also apparent in dash facia treatment. Dark colours are generally favoured to avoid reflections at night. In most instances, the instruments are grouped neatly above the steering column, and a hood or shroud is incorporated over them, again to avoid reflections on the screen. Some of the European manufacturers still employ the hooded type of headlamp housing, but the fact that this is not universally popular might be explained by the recent regulations introduced in Germany, which make it illegal to have projections liable to cause serious injury in the event of an accident.

Allemano

Allemano produce two bodies based on the Fiat 1200 chassis. One is a coupé and the other a four-seater. Both are of the two-door design; the coupé has only two side lights, while the four-seater version has four. As can be seen from the accompanying illustrations, the two designs are similar, but not identical. For example, on the coupé, the grille surround is extended further forwards, and the bonnet lid incorporates a divided air intake. There is a large opening at the front of this intake and two small openings, one each side of the division, at the rear. This arrangement gives through-ventilation, which should be useful in summer, but might be embarrassing in winter, because of the danger of carburettor icing. Fitted suitcases are available and can be strapped on the platform behind the two front seats. There is also ample space in the boot, the latch of which is released by a push-button between two door type handles mounted horizontally in line at the lower edge of the lid.

The four-seater saloon version of this car does not have an air intake on the bonnet. Instead, the plain surface of the lid is relieved by a chromium plated finisher strip, mounted centrally on it.

Another difference is that parking lamps are fitted in dished recesses on each side of the scuttle. At the rear, the quarter lights are separated from the rear window by fairly slender pillars. These quarter lights are pivoted at their forward edges and secured by toggle clips at their rear edges.

Inside the vehicle, there is a reasonable amount of head-room at the back, but the knee-room is rather restricted when the front seats are in the rear position. The rear faces of the squabs of the front seats are fitted with large, deep pockets closed by zip fasteners, which give them a neatly finished appearance. A large locker is fitted under the dash facia on the passenger's side. The headlining is of plastics material, backed by a fairly thick layer of glass fibre. Both front seat squabs are adjustable for angle, by means of knurled stop screws at their bases.

Beutler

A model recently introduced by this manufacturer is the Colombe version of the Simca Aronde. In overall conception, the design is basically a series of ellipses. At the front there is an elliptical radiator intake duct, fitted with a square-mesh grille. A horizontal, chromium plated bar, with a circular motif at the centre, is mounted on the square mesh, which is white in colour. The bonnet falls sharply to the upper edge of the elliptical opening, round which is fitted a chromium plated finisher strip. A wide air intake duct is fitted on the bonnet lid, which without it would look too plain.

This is the Allemano, four-seater, saloon body on the Fiat 1200 chassis. It differs from the coupé version, illustrated at the top of this page, in respect of the front end arrangement, canopy, windscreen, side lights and rear light

Horizontal features are accentuated at the rear end of the Beutler Colombe on the Simca chassis, and the horizontal line pressed in the rear quarter panel, and the crowns of the rear wing fins harmonize with this theme

Right: As seen in this view, elliptical features predominate in the design of the Beutler Colombe, and the side light arrangement and bumper sections are well chosen

Below: An unusual feature of the rear of the Allemano Fiat 1200 coupé, which is also illustrated at the top of the opposite page, is the employment of two handles, one each side of the push-button type lock on the lid of the boot

The body is also of elliptical form, as viewed from the side. This form is obtained by virtue of the downward sloping wing crowns both at the front and the rear, and also by the upward slope of the lower edges of the panels at both ends. An illusion of length is given by extending the headlamp housings well forward; in fact, they are slightly ahead of the bumpers, the ends of which are wrapped round the sides. The horizontal lines pressed in the panels immediately above the front and rear wing cutting lines accentuate the length of the wings and quarter panels. On the rear wings there are very fine fins extending up to form an almost horizontal line extending back from the waist on each side.

At the rear the boot lid and the panelling that surrounds it slopes down in much the same way as the bonnet at the front. This end, unlike the front, is not of elliptical form, but is rectangular in shape. The rectangular form is bounded by the two lamp housings on each side, the plain semi-elliptical section bumper below, and the angle between the skirt panel and the trailing edge of the boot lid surround panel above. A chromium plated finisher strip forms a frame round the number plate, which is illuminated by a lamp in a chromium plated housing above. The wheel nave plates are pressed to form an imitation spoke hub.

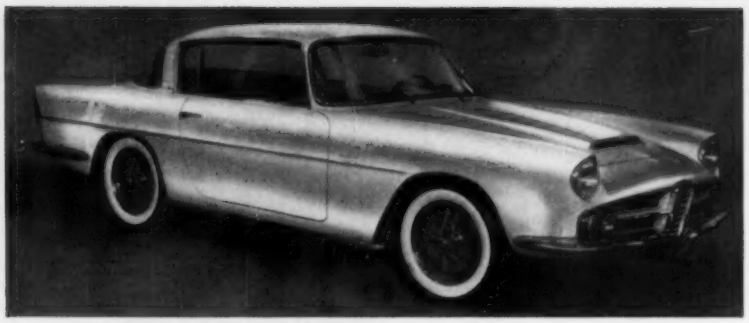
This vehicle does not have a wrap-round windscreen, but like most of the coachbuilt products, it is noteworthy for its extremely thin windscreen pillars. Since it is a two-seater, the roof line has been swept down fairly sharply at the rear. The shape of the side lights is in harmony with the general theme of the vehicle. There is a large drop-glass on each door, and the triangular rear quarter lights are hinged at their front edges and secured by toggle clips at their rear ends. An unusual feature on the vehicle is a rubber seal, fitted to the upper edge of the door waist, to prevent water running down the side light into the door. This could possibly have the disadvantage that pieces of grit might become trapped on the rubber and scratch the glass.

Inside the vehicle, the arrangement of the controls is good. An organ type throttle pedal is employed, and it is designed in such a way that the whole foot can rest on it comfortably and no effort is required to balance the throttle open in any position. This pedal is rubber-covered, so that the foot does not slide off.

All the trim is of hide. The seat cushions are long and their front edges are raised to give adequate support to the legs. The curved squabs are not only comfortable, but also support the occupants firmly when the vehicle is cornering. An unusual feature of the head lining is that it is of a very thin hide, perforated and mounted on what appears to be a sponge plastics. This material is like a sponge rubber, but less resilient. Presumably it has good sound absorption and heat insulation properties.

A sensible feature is the design of the sun visors, which, instead of being of a hard material likely to cause injury in the event of an accident, have a relatively flexible wire frame, which is padded and covered with a sheet plastics material.

An attractive contrast of maroon and cream is used for the interior trim. A simple instrument panel layout has been



Although the lines of the traditional Alfa Romeo radiator grille can be clearly distinguished at the front end of this Ghia Suisse body, the arrangement is modern in appearance

adopted, with the speedometer, petrol and water gauges in a common housing above the steering column; two warning lamps are also mounted on the dial. At the centre of the dash there are an ashtray and a radio, one above the other, and on the extreme right-hand side there is a glove box with a push-button catch.

A small occasional seat, the squab of which folds flat to form a platform for luggage, is installed at the rear. Chromium plated battens are fitted on this squab to support the suitcases. Eyes for straps to hold the luggage firmly in position are mounted on the heelboard and on the rear bulkhead.

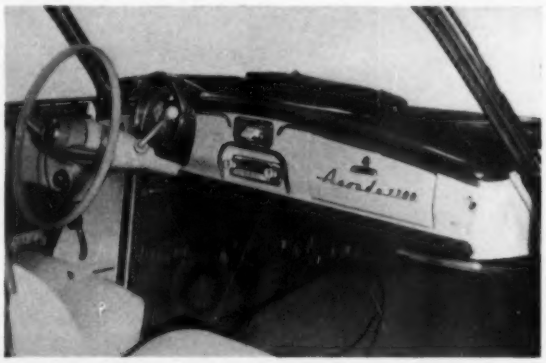
Above: Arrangement of the dash facia of the Ghia Suisse Renault Dauphine

Ghia Suisse

Ghia of Aigle produce a body on the Alfa Romeo chassis. A noteworthy feature of this is the highly successful adaptation of the Alfa Romeo traditional trefoil radiator grille arrangement to conform with the modern styling. The bonnet is extended forward of the wings, and overhangs the side grilles of the trefoil, which are practically as deep as the central one. The unity of the whole arrangement is ensured by the employment of three horizontal bars: one forms the upper edges of the side grilles and is in line with the top edge of the central grille; the second extends out from each side of the central grille, to bisect the side grilles horizontally and to carry the fog and pass lamps; the third is the bumper. As can be seen from the accompanying illustration, the headlamps are carried in recessed housings, so that they are well behind the bumper.

This vehicle, which is of the two-door design, has a wrap-round rear light, so the rear quarter light is very small. In fact, it is simply a hinged ventilating panel, pivoted at its forward edge, and secured by a toggle clip at its rear end. At the rear, the boot lid lock is mounted on the skirt panel and the bumper recessed locally to clear it. This sort of arrangement has been adopted recently by several coach-builders. Apart from the fact that it enables the edge of the boot opening to be brought lower down, without having to mount the lock on the lid, it seems to have but little practical merit.

Below: In the Beutler Colombe on the Simca 1300 chassis, the hood over the instrument dial obviates reflections on the screen at night



Ghia also manufacture a striking body on the Renault

On each side of the Ghia Suisse body built on the Renault Dauphine chassis, the direction indicator lamp forms the leading edge of the horizontal line pressed in the body panelling

This view of the rear end of the Ghia Suisse Alfa Romeo shows how the employment of a wrap-round rear light has restricted the size of the pivoted rear quarter light on each side

Dauphine chassis. This body is 13 ft 9 in long, as compared with the length of 12 ft 11 in of the standard production model, which weighs 25 kg more. Only the bonnet lid and the doors are of aluminium; the remainder is of sheet steel. Interesting features are the recessed headlamps with large chromium plated bezels at the front, and the direction indicator lamps, which are moulded to form a continuation of a line pressed in the sides of the vehicle. At the rear there is a grille, much like that which one would expect to find at the front end of the vehicle. Air intakes are fitted on each side behind the door pillars.

Graber

Graber have produced a number of two-door bodies on the Alvis chassis. One of these is a four-seater, with plenty of headroom for the passengers at the rear. This particular model, which is to be manufactured in England, has wide doors to give easy access to the rear seats. In all these models, the traditional radiator grille is retained. The four-seater version differs from the others in that the air intake apertures on each side of the central grille are smaller and more elongated. They are divided horizontally by a slender, chromium plated strip, which extends out to the direction indicator lamps on each side. These apertures and the grille are each framed with a chromium plated finisher strip.

The Graber Alvis Super coupé differs from the four-seater model in that its bonnet is extended to bring the radiator grille forward of the lamps. This lengthens the bonnet considerably and also helps to give the falling line that is so popular now. Like the models produced in previous years, this one has relatively large air intake ducts flanking the radiator grille, and the fog and pass lamps are mounted in them. It also has a large air intake duct pressed in the bonnet lid. This duct is divided by a chromium plated strip along its crown line.

An unusual feature common to all the latest Graber Alvis models is the windscreen demisting arrangement. A small channel section is pressed the full length of the dash facia adjacent to the base of the screen. In this channel, a number of holes about $\frac{1}{8}$ in pitch and $\frac{1}{4}$ in diameter are punched. These holes form the jets through which the demisting air is blown over the whole width of the curved windscreen.

This appears at first sight to be attractive, and in fact it may well be; nevertheless, care would be needed in the design and development of such a device, because the resistance to the air flow through the multiplicity of small holes would be appreciably greater than that through, for instance, two or three large slots.

Pinin Farina

Pinin Farina's models this year, like those that he produced last year, are noteworthy for their simplicity of line. One of his outstanding vehicles is that based on the Cadillac chassis. This design, which is of the two-door, two-light layout, is noteworthy because of the success with which a pleasing and well-balanced appearance has been obtained without resort to elaborate styling devices. Horizontal features are accentuated at the front end, the only readily visible features of the grille being a number of parallel chromium plated strips. These strips are mounted horizontally and are spaced apart by vertical bars, which are practically invisible from the front. Side lamps and direction indicators are carried in two rectangular bezels mounted one on each side of the grille, immediately below the twin headlamps. The bumper section matches the rounded leading edge of the bonnet lid, which overhangs the grille. Over-riders of unusual form are employed, as can be seen from the accompanying illustration; they are designed to harmonize with the twin headlamp arrangement above.

An accentuated form of dihedron layout has been adopted for the body sides, to give an illusion of length. The accentuation of this line has been effected by incorporating a concave curvature in the panelling immediately above and below it; the dihedral angle is more acute at the rear than at the front. This arrangement has been adopted so that, as seen from the front of the car, the line does not entirely disappear in the distance at the rear, but becomes thinner and accentuates, in a most subtle manner, the impression of distance. It is features such as this that are the stamp of a master of the stylists' art.

At the rear, fine tail fins are incorporated. Like the canopy, they are painted cream to contrast with the black of the remainder of the body. The lines of the crowns and trailing edges of the fins and rear wings are accentuated by

The outlet grille for the air from the engine cooling system on the Ghia Suisse Renault Dauphine is styled in much the same way as a forward-mounted radiator air intake

The overall conception of the design of the Florida IIA is much the same as that of its four-door predecessor, with the centre pillar extending only up to the waist, but now it is a two-door model

The traditional Alvis radiator grille is retained in this Graber model, but it is carried on a forward extension of the bonnet. This version, which is a full four-seater, with ample headroom, is to be manufactured in Great Britain

As viewed from the rear, the different versions of the Graber Alvis are much the same. This model is basically a two-seater, but two fairly comfortable occasional seats have been provided at the rear, although there is less headroom over them and access to them is not so easy as in the model shown above

The simple dihedron treatment has been applied on the sides of the Florida IIA and a line is pressed along the front wing crowns to accentuate the highlights

Interesting features of the Pinin Farina Cadillac are the modified dihedron shape of the sides and a fine line pressed in the crown of each front wing; these devices give subtle effects with highlights

the use of fine, chromium plated finisher strip. A rather heavier chromium plated strip is fitted along the cant rail and down the door shut pillar to a level slightly below the waist, whence it extends to the extreme rear end of the vehicle. This chromium plated strip, in conjunction with the cream fin panel above it, is in harmony with the lines of the wrap-round end of the rear bumper. The horizontal lines of the front end are echoed at the rear of the vehicle by the finely rounded section of the horizontal, overhanging trailing edge of the boot lid and this, in conjunction with the plain bumper section below it, accentuate the horizontal features connecting the vertical lines of the large tail lamp housings.

An outstanding feature of the design is the simplicity of the trim layout on the doors. All handles and winders have been dispensed with, and the only control mounted on each door is the lever to actuate the lock. This lever forms a forward extension of the arm-rest and thus harmonizes with the general lines of the trim. It is so positioned that there is no danger of its being actuated accidentally. The window actuation is controlled by electric switches, and so also are the seat movements, which include adjustments to the squab angle, as well as the fore-and-aft location of the whole seat assembly.

The arrangement of the transparent, hinged ventilating panels at the leading edges of the doors is interesting. They are of rectangular form, pivoted approximately at the centres of their upper and lower edges. The trailing edge of the glass does not have a glazing rail, and the unusual feature of the arrangement is that when the panel is closed, this trailing edge is approximately ¼ in clear of the leading edge of the drop glass in the door.

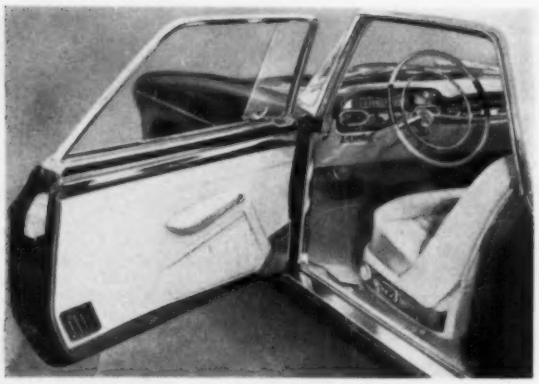
The steering wheel is of the safety type. It has two spokes forming an obtuse angle V, which is echoed lower down the column by the two, lever type controls, one for the lamps and the other for the automatic transmission. The wheel is of dished form, that is, the hub is forward of the rim which, being fairly resilient, is less likely to damage the driver's chest in the event of a collision or other form of accident.

A wrap-round windscreen and rear light are employed. The windscreen pillars and glazing rails in general are all of relatively thin section by comparison with those on cars of American design. An interesting feature is the way in which the chromium plated strip on the tail fin is continued up, to conceal the trailing edge of the canopy, over the top of the rear light. This facilitates the finishing of the junction of the canopy and the window frame. Wire wheels are employed, and these, together with the relatively open, flared wheel arches, give the vehicle its light appearance, which is so unusual for a body on such a large chassis of American design.

The Florida IIA is designed on much the same lines as its predecessor and the Flaminia, which were described in the May, 1957, issue of *Automobile Engineer*, but is lighter and more compact and is of the two-door layout. Inside, there is ample accommodation for four passengers. The simple dihedron angle device is retained on each side; in addition, there is a line pressed in the crown of each front wing. Although this line is barely discernible, it gives rise to clearly defined highlights that greatly enhance the beauty of the design. In fact, a commendable feature of this vehicle is the way in which the body panels have been designed to give good effects by virtue of vivid highlights on the black paintwork. Chromium plated finisher strips are used sparingly also to help to make adequate contrast on what would otherwise be a plain body.

Inside, the arrangement of the trim of this body is of

A full-width radiator grille has been adopted on the Pinin Farina Cadillac, and the twin side-by-side headlamps overhang it on each side of the sloping bonnet



The Pinin Farina Cadillac door is entirely free from winders and levers

particular interest. The sides and door panels are covered with a material that both feels and looks like a wool-based cloth, whereas it is plastics sheeting with a cloth finish embossed on it. The screen head rail and two horizontal rails, one forming the upper and the other the lower edge of the dash facia, are soft-padded and trimmed with black hide. This black trimming, which also extends round the waist rails, contrasts well with the light blue cloth below it. A broad chromium plated strip is fitted on the waist rail on each door. Below the waist there is a locker for maps, gloves and small parcels, on each door. An unusual feature of this locker is that it comprises a rectangular frame and lid assembly, mounted on the door trim instead of in a cut-out in the panel.

Winder-operated drop lights are fitted both to the door and the rear quarter on each side. The last inch of the movement of the quarter light, as it is being raised, brings it forward rather more than one inch to overlap slightly the inner face of the trailing edge of the glass on the door. This overlap obviates the need for a rubber seal between the two. At the rear, two windscreen wipers are fitted to the rear light, each wiper has two arms, one operating on the inner face and the other on the outer face of the glass. This arrangement provides effectively for interior demisting as well as for clearing the water off the exterior of the glass in wet weather.

The TV1100 model is still in production, after a run of many years. However, it has now been modified and is also available with the Fiat 1200 engine, the chassis, of course, also being manufactured by Fiat. Although, so far as exterior appearance is concerned, the vehicle is not so very different from its predecessors, some features of the interior trim are of particular interest. A special paint is employed on the dash. This paint forms automatically a matt finish, almost like a stippled surface, as it is sprayed on; it is particularly useful as an anti-reflection device, and at the same time is attractive aesthetically. A large ashtray is mounted on the propeller shaft tunnel, between the driver and the passenger. A push-button actuated catch secures the hinged lid of this ashtray, which springs open automatically when this button is pressed.

To give easy access to the rear seats, the front squab and seat pan are interconnected by a simple link arrangement, so that when the squab is moved forwards, the seat pan, which is mounted on rails, also slides forwards. As on some of the other models by Pinin Farina, a chromium plated drip channel is mounted on the waist rail, immediately below the hinged ventilating panel adjacent to the leading edge of each door.

Originally, both the boot and bonnet lids were of plastics material, but a metal bonnet lid is now fitted, because radio interference was experienced when the plastics one was employed. The boot lid will also be made of metal in future, mainly because colour matching of the different panels is difficult when some are of laminated plastics and others of metal.

Pinin Farina also makes an extremely attractive body on the Alfa Romeo chassis. At the front, horizontal features predominate. The bumper is of plain section and echoes the line of the forward extension of the bonnet surround, which forms the upper edge of the grille opening. Between the two, the radiator grille is formed entirely of horizontal bars, of chromium plated U-sections. It extends not only the full width, but also round the sides of the wing panels, to within 2½-3 in of the front edge of the wing cutting line. As on the Florida, the wing crowns are clearly defined by highlights each side of a line formed by a slight change of section along the line of the highest contour. The line of the long wrapped-round ends of the front and rear bumpers is continued through the wheel hubs to a chromium plated strip at the level of the top of the door sill.

This vehicle differs from the other Pinin Farina models in

As can be seen from these two views of the Pinin Farina Alfa Romeo, fussy chromium plated decoration is unnecessary, even on the larger vehicles

On the door of the Pinin Farina Florida IIA, the locker for maps is mounted on the trim panel instead of in an aperture in it

that the wing crown line rises from the forward end, to the front pillar, and then falls towards the rear pillar, then it rises again and falls gently to the trailing edge of the fairly low fins type wing. In other words, the continuous waist line that has become so popular recently has not been adopted in this design. The rear lamp housings are of chevron form, as viewed from the side. Their red transparent plastics covers are moulded to conform with the trailing edges of the wings. The rear end of the vehicle is exceptionally plain, being decorated mainly by a large chromium plated boot handle, which also serves as a housing for the rear number plate illumination lamp.

The exterior of the vehicle, like that of the Cadillac and the Florida is painted black. Inside, the trim is in green hide, and the headlining is a very pale egg-shell green. The floor coverings are fawn coloured carpet. A $\frac{3}{4}$ in thick sheet of sponge plastics material is fitted under the carpet over the whole of the floor, and rubber mats are also fitted in the front. The sponge under-layer is a useful feature not only from the point of view of noise absorption, but also gives a luxuriously soft feel to the covering. At the rear, there are occasional seats with very thin padded cushions. These rear seat pans are hinged at their forward edges and can be folded forwards to cover the footwell, and thus form a fairly large platform for luggage. Despite the low lines of this vehicle, there is adequate headroom over the rear and front seats.

Touring

The Touring Superloggera Alfa Romeo chassis has a number of distinguishing features. At the front, the familiar Alfa Romeo trefoil radiator grille arrangement is employed, but the apertures on each side of the central grille are elongated to obtain a modern appearance. The lamp housing on each side, for the fog or pass lamp and indicator lamp, is of interest. Both lamps are mounted together, one above and the other below a horizontal division, in a single, chromium plated bezel. The upper part, which is the smaller portion, houses the direction indicator, while the lower part is used for the fog or pass lamp. An air intake duct is formed on the bonnet lid. This is divided in two longitudinally, by a V-section pressed in it, and a chromium plated strip is mounted in the base of the V.

At the rear, the bumper is recessed at the centre to provide clearance for the boot lid lock, which is mounted on the skirt panel. The wheel arrangement differs from most of the other models described, in that plain chromium plated nave plates are employed and the wheel disc is ventilated by eleven holes round its periphery to allow cooling air to flow from the finned brake drums.

Touring make a two-door, four-seater hard-top and a drop-head coupé, also with two doors, on the Maserati chassis. To accentuate the downward slope of the bonnet, the low radiator grille is placed well forward, so that the skirt panel and the front of the bonnet surround are in front of the headlamps and the fog and indicator lamps. An air intake is incorporated on the bonnet lid and, as on the Alfa Romeo body, is divided by a V-shape pressed into it, but in these two models a chromium plated strip is not used to accentuate this line. Highlights on the front wing profiles are accentuated by a line pressed along the crowns. This line is continued through the waist to the fin type rear wings, which are surmounted by a chromium plated finisher strip.

The interior is trimmed in black hide and the dash facia is also finished in black. A large grab handle is fitted to the facia, in front of the passenger's seat. Fawn coloured carpet is used for the floor covering. Both these vehicles have

The Pinin Farina Fiat TV 1100 model has recently been modified and is now available also with the Fiat 1200 engine installed. A noteworthy feature of this vehicle is the slenderness of the pillars of the wrap-round windscreen as well as those of the two rear quarters

Comfortable seats and a large grab handle on the dash facia are features of this Touring body on a Maserati Gran Turismo chassis

ventilated wheels, not unlike those used on the model previously described. They also have a large scuttle vent on each side.

A noteworthy feature is the mounting of a small lamp under the centre of the bonnet lid, to illuminate the engine at night when the lid is opened. Another unusual feature on this vehicle is the incorporation of a demister duct for the rear window. This duct is, of course, on the parcels shelf at the back. At the front, there are three demister ducts for the wrap-round windscreen.

Vignale

Vignale have produced a two-door coupé on the Lancia Nardi chassis. This vehicle has a large number of unconventional features. It has been exceptionally well streamlined, without sacrifice so far as appearance is concerned. The front end is a fairly dark blue, while the remainder is of a lighter blue, both being of a faintly greenish hue.

There is no bumper at the front, and the headlamps are housed in the radiator grille opening, the edges of which are well forward of the wings. Although the bonnet line slopes down to the grille, the wings are slightly elevated, so that they can be seen readily from the driver's seat. A direction indicator lamp is mounted in a recess, low down on the side of each wing. The two recesses are each lined with a chromium plated pressing to reflect the lamp signal; however, it is questionable as to whether the angular range through which this indication is visible is adequate.

An air intake vent is fitted on the leading edge of the bonnet lid to provide clearance for the engine. The trailing edge of the lid is about ¼ in above the scuttle to allow air to pass out from under the bonnet. This helps to keep the temperature in the engine compartment down in hot weather, and possibly assists in de-icing the screen in winter. The line of the trailing edge is continued by a line pressed in the scuttle surround panel and continued round the sides, along the upper edge of the door, and almost to the extreme rear edge of the wing, where, as can be seen from the accompanying illustration, it turns down and doubles back on itself to form the boundary of a broad band of dark colour just below the waist. Forward of the door, the line is turned down and runs approximately parallel to the sloping rear edge of the wing cutting line. It then turns back again at the level of the top of the sill, to form another band of dark blue, parallel to the waist band. The vent on top of the bonnet lid is painted a light blue.

Most of the unconventional features of this vehicle concern the glazing. An unusually steeply sloping screen is employed and it has wrap-round sides. There are no glazing rails round the drop lights in the doors, nor is there one on the leading edge of the rear quarter light. The glasses overlap a small fraction of an inch when the doors are closed, but there is a gap of approximately ⅛ in between the inner face of the door-glass and the outer face of the rear quarter glass. The top of the vehicle is of cabriolet type construction, but with a tinted glass sliding panel instead of the fabric folding head. This panel can be slid to the rear to a distance of only 4 or 5 in. The rear light, like the windscreen, is steeply sloping and blends with the streamlined form of the body. It has no glazing rail at all at its upper edge, where it laps under the sliding tinted glass roof.

On each side, there are direction indicator lamps at the level of the trailing edge of the cant rails, something like the arrangement on the Citröen DS19. These lamps are mounted at the top of shallow, channel section, chromium plated pressings, which have louvres in them, to make them look like ventilators. In fact, they are not used for ventilation at all, since the gap between the upper edge of the rear light and the sliding glass is adequate for that purpose.

At the rear, a two-piece bumper is employed, its upper surface being channelled to clear the rear lamps. The rear wings are of the finned type and have two lines pressed in their outer flanks. One marks the boundaries of the rear portion of the length of dark coloured band, just below the

Two views of the Touring Maserati 3500 Gran Turismo, showing the forward-extended radiator air intake at the front and the twin exhaust tail pipes projecting from the rear

Touring produce this smart body on an Alfa Romeo chassis. It has the currently popular divided air intake arrangement on the bonnet

Illustrated below is the rear end of the Vignale Lancia Nardi, which has a sliding roof of tinted glass and dummy ventilating louvres on each side of the unusually large rear light

waist; the other extends horizontally from the rear, over the wing cutting line, and then turns down to run out diagonally towards the rear lower corner of the door.

Vignale have also produced an extremely attractive coachbuilt body based on the Triumph TR3 chassis. At the front, the bumper ends are turned up to form a cradle in which the radiator grille is mounted. Behind the large mesh chromium plated grille is a screen of expanded metal, which is painted black so that it can hardly be seen. A horizontal, chromium plated bar is mounted on the front of the grille, approximately mid-way between its upper and lower edges. The direction indicator lamps, which are also mounted on the grille are in line with the ends of this bar; and the headlamps are in hooded housings at the front ends of the wing pressings above the bonnet surround. To obtain a low bonnet line, it has been necessary to incorporate in the lid an exceptionally large air intake duct to clear the top of the engine. Air outlet louvres are punched, towards the rear, on each side of the central chromium plated strip on the duct.

The vehicle is finished in two contrasting colours, black and cream. As can be seen from the accompanying illustration, the plainness of the sides is broken up by a black band extending from front to rear. On each side, this band tapers from a point at the top of the upswept end of the front bumper, becoming wider as it goes to the rear until, at the rear edge of the fin type wings, it is broadened to cover the full depth of the side panel. A thin line, cream in colour, is painted along the crown of the wing. At the rear of the vehicle, a cradle type bumper layout has been adopted to conform with that at the front. The centre of the bumper is recessed to clear the boot lid lock.

Both the seats and the doors are trimmed with leopard skin and black hide, with cream piping. A Porsche type steering wheel is employed. This has a large diameter hub from which the three spring steel spokes radiate to the slender rim, also of spring steel, but covered with timber. Thus the rim of the wheel is flexible and the hub is large in area, so that the driver is not likely to be seriously injured if he should be projected against it in a collision.

An unusual feature of this vehicle is the arrangement of the rear light. This is of tinted safety glass with swept round sides. At the base of its trailing edge it is retained by hooks on the tonneau and, at the leading edge of each of the wrapped-round sides, a knurled thumb screw secures it. A power-operated hood is stowed in the tonneau. Before this hood can be raised, the thumb screws are undone, and the glass is removed; it is then replaced after the hood is up.

Vignale have also recently produced two bodies on the Fiat 1200 chassis. One is a four-seater saloon, and is called the Desirée, while the other is an estate car, called the Gardener Car. The front ends of both are identical. As on a number of other coachbuilders' products, the air intake duct is divided longitudinally in two. In this particular instance, the division is formed by pressing a channel section along the longitudinal centre-line of the top of the duct, and painting it a lighter colour than that of the surrounding panels. A band of dark colour extends from the parking light on the side of the wing, just behind the headlamp, to the extreme rear end of the vehicle, where it broadens and terminates at the rear lamp housing. In both vehicles there are reclining front seats, the squabs of which can be laid back against the leading edge of the rear seats to form a bed. Separate cushions are provided for pillows.

The Vignale Lancia Nardi has been well streamlined without sacrifice so far as appearance is concerned. A direction indicator lamp is recessed in the base of the wing on each side

Left: The arrangement of the pillars and side lights is among the noteworthy features of the Vignale Gardener car, the rear end of which is illustrated at the top of the opposite page

Distinguishing features of the saloon version are the extremely thin windscreen pillars and rear pillars. In fact, the all-round visibility is exceptionally good. The estate car has two doors at the front and a third on the rear end. There are only two lights on each side, one, of course, being on the door, and the other behind it. An attractive side light arrangement has been adopted, the centre pillar being of tapered form, with the small end of the taper at the waist and the large end at the cant rail. With this arrangement one edge of the centre pillar is approximately vertical to guide the sliding glass in the front of it, while the slope of the other edge is such as to make the fixed rear window more or less symmetrical in form. At the rear, the door is hinged at the top and has a telescopic spring-loading device on each side to assist in lifting it and also to support it in the open position. The dash facia is common to both models. It is of the hooded or shrouded design, popular in the American cars, the hood extending the full width and down each side.

The two illustrations below show the front and rear ends of the Viotti Fiat 500, the wings of which are extended forward and to the rear to give an illusion of greater overall length

Viotti

Among the bodies manufactured by Viotti, there is one based on the Fiat 600 and another on the Fiat 500 chassis. Both are difficult designs for a coachbuilder to develop, because of the extremely small size of the chassis. The 600 version is of the elliptical type of design, that is, both its front and rear ends are of rounded form so that, as viewed in either front or side elevation, its profile is approximately elliptical, as opposed to the rather more square or parallelogram shapes, which are becoming increasingly popular.

The arrangement of the front end can be seen from the accompanying illustration. An interesting feature is the method of breaking up the plainness of the bonnet top. This is effected by pressing an inverted channel section along the top of the lid, instead of an air intake. The front of this channel is extended down and its edge passes completely round the circular "600" motif at the centre of the skirt panel. A chromium plated strip is mounted along the centre-line of the pressed portion.

At the rear, a similar shape is pressed in the lid of the engine compartment, but this is, in fact, for ventilation. Air outlet

Above: The Viotti Fiat 600 is basically of the elliptical type of design and presents quite a pleasing appearance for such a small car

Left: Vignale manufacture this two-door, four-light body, which is called the Desirée, and which is mounted on a Fiat 1200 chassis

louvres are also punched in the lid on each side of the number plate. There are two air intakes, one on each rear quarter panel. Because of the trend towards falling bonnet profiles, it would not be surprising to see dummy air intakes on the bonnet lids of future models based on rear-engined chassis; this might help to give more clearance for luggage.

The 500 version is, perhaps, more interesting because in this design great pains have obviously been taken in the employment of styling devices to give an illusion of length. At the front, the skirt panel is raked forwards and the crowns of the wings extend forwards and overhang the lamps to form hoods of the form currently popular on American vehicles. A similar arrangement is employed at the rear, but the rake is not so pronounced, and the chromium plated bezels form the hoods over the lamps.

Zagato

Zagato have produced an unusually well streamlined coupé body on the Jaguar XK150 chassis. However, from the point of view of workmanship and finish, the model exhibited at Geneva is not up to the standard of the bodies produced by Jaguar, which would be difficult to beat. This Zagato version has a falling bonnet line. Extensions on each side of the Jaguar type radiator grille blend well into a modern streamlined style. A small air intake duct is fitted on the bonnet lid. The headlamps extend forwards to a position above the leading edge of the bumper. The chromium plated glazing strips round the windscreen are of shallow section, so that the surface of the glass is only about ¼ in below that of the surrounding metal panels, and the streamline air flow is, therefore, but little disturbed.

Curved side lights are employed in the doors. Problems with regard to accurate register between the edges of the glass and the seals at the leading and upper edges are overcome by the use of a transparent plastics deflector strip, mounted on the upper portion of the B-post, so that even if the edges of the glass do not seal well, there is no draught because the air is deflected by this strip. Extremely small, occasional seats, suitable for tiny children, are fitted at the rear. The rear squab, which is not padded but simply covered with a suede-type leather, can be folded forwards horizontally to form an extension of the platform of the boot.

Above: The ventilator outlets behind the rear quarter lights and the shape of the canopy are interesting features of this Zagato body

Right: The door at the rear end of the Vignale Gardener car, which is hinged at its upper edge, has two balancer springs, one on each side

Below: The headlamps of the Zagato Abarth Fiat 750 are fitted behind moulded transparent plastics covers

The object of this arrangement is to make provision for stowing long objects, such as skis or golf clubs.

Zagato have also built a body having a number of unusual features, on the Abarth Fiat 750 chassis, A pair of large air intake scoops are incorporated on the leading edge of the lid of the rear compartment that houses the engine and, forward of these scoops, there are two bulges on the roof, one on each side, to clear the heads of the occupants. One of the scoops on the lid deflects air down to the carburettor intake, while the other has a baffle fitted in it to deflect the air down further to the radiator intake. Both are open at their lower ends to form air outlets and thus to give through-ventilation to the engine compartment. There are two more outlet louvres, one on each side, immediately behind the rear quarter lights, for ventilation of the interior of the car. The side lights are curved and, as on the Jaguar chassis, their leading and upper edges are shielded by a transparent plastics deflector strip. The headlamps are recessed in the leading edges of the front wings, where the streamline form is preserved by the employment of a transparent plastics cover of suitable shape.

Wire wheels are employed to give adequate ventilation round the brake drums on this Jaguar chassis fitted with a body by Zagato

Machining Mechanical Details

Some of the Advanced Production Methods Employed by Vauxhall Motors Ltd. in the Manufacture of Engine Components

AN important part of the Vauxhall expansion project, which was described in general outline in the April, 1958, issue of this journal, is the concentration of all mechanical detail production and assembly in a single factory building. This concentration has been accompanied by a very extensive re-tooling programme in order that full advantage may be taken of the most advanced production techniques. These notes will deal with only a few of the many interesting developments that have recently taken place.

When this factory building was first brought into commission in 1950, it was laid out for the production, among other things, of the first Vauxhall over-square four-cylinder and six-cylinder engines for Wyvern and Velox cars respectively. These power units remained current until 1957, when a new four-cylinder engine was introduced for the Victor and a new six-cylinder for the Velox and Cresta models. As was the case with the engines introduced in 1950, the new four- and six-cylinder engines have as many common parts as possible, but in planning the production of certain components for the new engines there has been a marked change in methods.

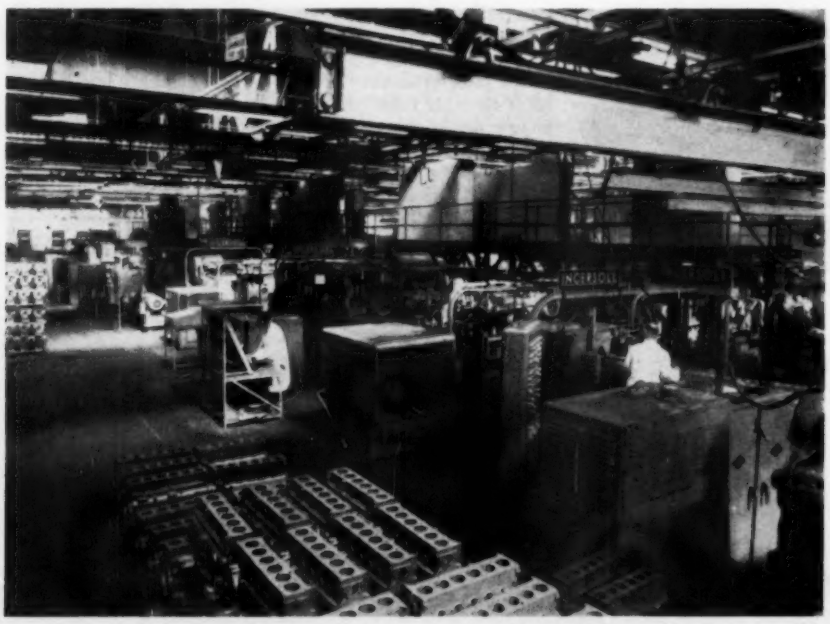
In 1950 it was decided that the machining facilities should be such that four-cylinder and six-cylinder blocks and heads could be processed in the order that would meet assembly schedules. This, of course, has the advantage of minimizing the stock of work in progress, but at the same time it ruled out the possibility of using automatic in-line transfer machine. Briefly, the arrangement was to use individual machines, many with multiple heads. Many of the machines in the block line were suitable for both types, but at certain operations it was necessary to have separate machines for each type.

In contradistinction to this, in the new layout very great use is made of automatic in-line transfer machines for the production of cylinder blocks and heads. At present, only a single line is needed to meet the scheduled output and, therefore, it is now necessary to produce a batch of one type and then carry out tooling adjustments to produce a batch of the other type. The introduction of transfer machines has, of course, led to some increase of investment in work in progress but it has also greatly decreased the labour force required. It has also increased the output potential because it eliminates much of the handling time between machines.

Furthermore, the outstanding success the Victor has won in export markets and the steadily increasing popularity of the Velox and Cresta models suggest that the time may not be far distant when the demand will exceed the production capacity of the single line. Then, of course, it will be feasible to install another line, so that there will be one line for four-cylinder blocks and another for six-cylinder blocks. In point of fact, floor space has been left available for just such an eventuality.

The great use made of automatic in-line transfer machines is the most obvious feature of the production layout. Less spectacular, and in some respects much more interesting, are the methods applied where the processes are such that individual machines must be employed. In cases of this character, great use is made of magazine loading and automatic ejection with, according to the nature of the component, provision of some sort for non-manual transfer of work from one machine to the next. Overhead mono-rail conveyors, slat-conveyors and chutes are among the devices used for non-manual transfer of work from machine to machine. Examples will be given later in these notes.

Great advances have also been made in inspection techniques. Completely automatic inspection devices are widely used. Many of these devices have been specially developed



Seven automatic in-line transfer machines are used in the production of both four-cylinder and six-cylinder blocks for Vauxhall passenger cars

by Sigma Instrument Co. Ltd., Letchworth, for specific applications. Some will be described in detail later in these notes.

Cylinder blocks

It is not necessary to describe in detail the machining sequence for cylinder blocks in detail, since it is essentially one that has frequently been described. Therefore, only a brief account to emphasize certain major points will be given of the block line.

As a preliminary to the machining proper, locations pads are machined on a special three-spindle machine. The block casting is then loaded on to a 13-station Ingersoll machine on which a number of milling and drilling operations are performed and the bores are rough machined. Among the elements machined are the main bearing tenon faces, and before the block enters the second transfer machine in the line, these faces are checked on Solex inspection equipment.

The casting then passes to a six-station Ingersoll in-line transfer machine on which the main operations are milling the front and rear end faces. On leaving this machine the casting again passes through an inspection station before it is loaded into the next machine, a 15-station Barnes machine tooled for a multiplicity of drilling, reaming and tapping operations. At a station immediately before the tapping is carried out, provision is made for automatically blowing out swarf from blind holes and for probing them for depth. At the end of the machine the component is automatically ejected for transfer along a powered roller track to the next machine.

Chief interest in the next machine lies in the fact that it was originally two Barnes automatic in-line transfer machines, one with 33 stations and the other with 15 stations. It has, however, been found possible to link these machines so that in effect they now form one 48-station machine. From this combined machine, the component passes to a seven-station Ingersoll machine tooled for finish machining the camshaft bores and semi-finishing the main bearing bores.

After passing through an inspection station, the casting is then automatically transferred to a special seven-station machine. On this machine the bushes are pressed into the camshaft bores, the main bearing and camshaft bush bores are finished to size, two register dowel holes are reamed, the distributor and oil pump bores are finished to size and the rear end is finish milled. From this machine the casting passes to an inspection station where the camshaft bush bores, the main bearing bores and the distributor bore are checked for diameter. The inspection device is linked with the machine in such a manner that if the bores fail to conform to specified limits, the machine is automatically stopped. Additionally, Solex air gauging equipment is employed for checking the diameter and alignment of the camshaft and main bearing bores. This completes the automatic in-line transfer machining on the cylinder block.

As can readily be understood, swarf disposal from a line of this character can create quite a problem. In this case the problem has been solved by mounting the machines over a pit in which there is a swarf conveyor. It may also be remarked that at certain idle stations, following operations that do not allow the swarf to fall freely away, the casting is automatically tilted sufficiently to let the swarf fall out and then returned to position for transfer to the next working station.

Individual machines are used for the remainder of the operations. The cylinder bores are semi-finished on an Asquith machine, the head face is finished on a Cincinnati horizontal broaching machine, the cylinder bores are finish machined on an Ex-Cell-O fine borer, the tappet bores are finished on an Archdale machine, and finally the bores are honed on a Micromatic hydrohoner.

Main bearing caps

In some respects the set-up for machining the main bearing caps ready for assembly to the cylinder block is the neatest transfer line in the factory. The caps are obtained from outside suppliers as cluster castings of two types, one to make four caps for the six-cylinder engine and the other to make three caps for the four-cylinder engine. Here we shall deal only with the latter.

The production set-up is such that from only two transfer machines the rear cap is produced ready for assembly, while the front and intermediate caps are complete except for one relatively minor operation on each. The first of the transfer machines comprises three standard Weatherley

Another of the transfer machines for cylinder blocks. Here a 33-station machine and a 15-station machine have been linked to form a single integrated unit

This Weatherley Oilgear transfer machine is used for pressing the valve guides into the cylinder heads

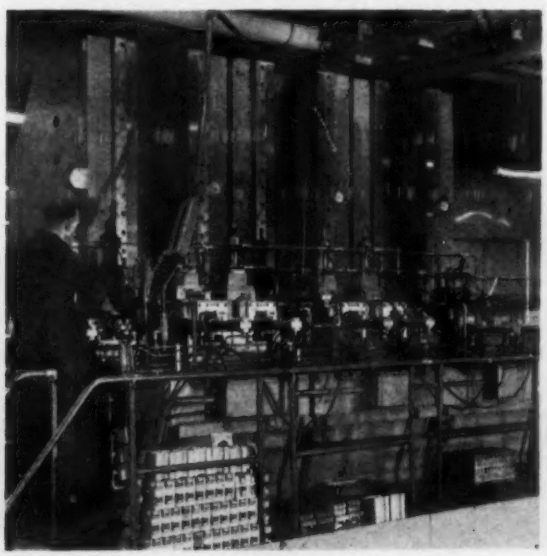
Oilgear double-slide, vertical surface broaching machines, linked by transfer mechanism to form an integrated unit.

In contradistinction to the normal in-line transfer machine, in which the work travels in a straight line through the whole length of the machine, on this Weatherley machine the working position is not the same as the transfer position. Instead, at each working station the work is moved forward to the broaching position and at the end of the broaching stroke is automatically retracted to the transfer position.

The cluster casting is loaded vertically into the machine with the bore and joint face towards the tools. At the first working station the half bore is broached and at the second the joint face is machined. Between the first and second machines there is an idle station where there is a simple mechanism to turn the casting through 180 deg about the vertical axis. This, of course, brings the top face towards the tools.

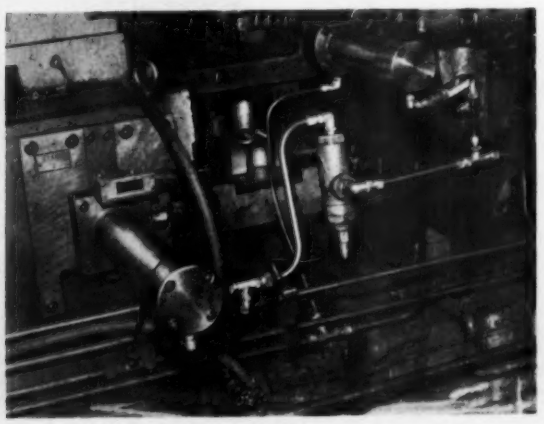
At the third working station, that is, from the first slide on the second machine, the top faces are broached, while at the fourth working station the sides and tenon width are broached. Between the second and third machines there is another idle station at which the casting is automatically turned through 90 deg to lie on the joint face with one end towards the tools. At the fifth working station one end face is broached and cork seal slots and a location-Vee are also broached. During transfer from station five to station six, the casting is turned through 180 deg to bring the other end face into position for broaching at station six.

When the broaching operations are completed, the cluster casting is automatically ejected into a chute that leads to the loading end of a Kearney and Trecker 20-station, automatic in-line transfer machine. This machine is magazine loaded. It is chiefly tooled for drilling, reaming and counterboring operations on the bolt holes, but milling operations are

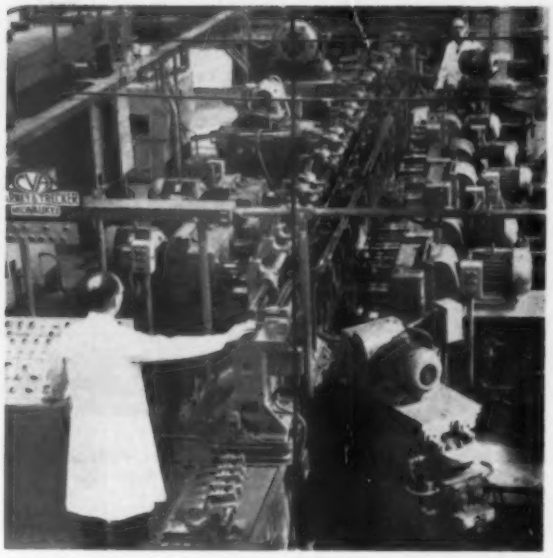


Left: Three Weatherley Oilgear surface broaching machines with transfer mechanism for main bearing caps

Below: At this station on the Weatherley machine, the casting is turned through 180 deg to present other faces to the broaches



Above: The loading mechanism and transfer bar of the Kearney and Trecker machine



Right: Kearney and Trecker transfer machine for bearing caps

carried out at three stations and at the final working station the unit casting is sawn to form three bearing caps.

Cylinder heads

Considerable use is made of automatic in-line transfer machines on the cylinder head line. Since, however, the operation sequence follows normal practice, it is not necessary to follow it in detail. Brief reference may, however, be made to an unusual and interesting Weatherley Oilgear transfer machine used for inserting the valve guides. At the first station on this machine there is a brush-out unit that cleans the bores in the cylinder head casting. The guides are loaded into a magazine at the second station and are part-pressed into the casting at the third station and are finally pressed home at the fourth station. Indication is automatically given if the interference fit of the guide in the casting is too light.

Crankshafts

Crankshaft machining is a new departure for Vauxhall Motors Ltd. Previously, shafts in the fully machined condition were obtained from outside suppliers; now the whole of the machining is carried out in the Vauxhall works. There are two complete machine lines, one for four-throw and the other for six-throw shafts. These notes deal with the machining set-up for four-throw shafts.

The first machining operation is to centre the ends of the forging to give locating and mounting points for subsequent operations. Here it should be mentioned that the mass centre, not the geometric centre, is used. This is because experience has shown that shafts machined from mass centres usually require less final balancing. However, it is worth pointing out that it is not always advisable to use the exact mass centre; in some cases a slight offset of the machined centres in relation to the mass centre proves advantageous. To centre according to mass entails dynamic balancing, and in each line there are two machines equipped first to balance and then to centre the shafts. One machine was developed and built in the Research Division of General Motors; the other is a Schenk automatic balancing machine.

After it has been centred, the shaft is transferred to a Kearney and Trecker five-spindle milling machine, on which location notches and flats are milled on certain webs. This is a most important operation, since it provides location registers for subsequent work. Because of the importance of this operation there is, adjacent to the milling machine, a special Sigma gauging unit for frequent checks. This unit will be described later.

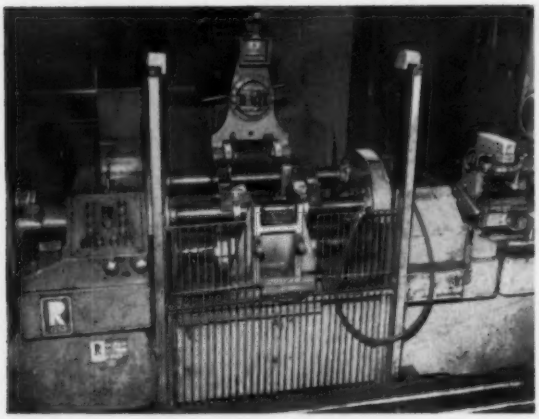
Four fairly conventional operations follow. At the first, the three main bearing journals and all other diameters having their centres on the axis of the shaft are rough and finish turned on a single centre-drive Le Blond crankshaft lathe. At the second, these diameters are rough ground on a Landis multi-wheel grinder. From the Landis, the shafts are transferred to a double-spindle Le Blond lathe, on which the crankpins on two shafts are rough turned simultaneously. Following this, and on a similar type of machine, the crankpins are finish turned.

At this stage, the shaft is transferred to an Archdale in-line transfer machine for drilling the oil holes. This machine has four working stations and is arranged for double indexing, so that one shaft is drilled at the first and third stations, the other at the second and fourth. At the completion of the drilling, the shafts are automatically ejected on to a ramp down which they move to a position convenient for the next operation, which is a check and, if necessary, a correction for straightness. The outside diameters of the webs are checked at the same time.

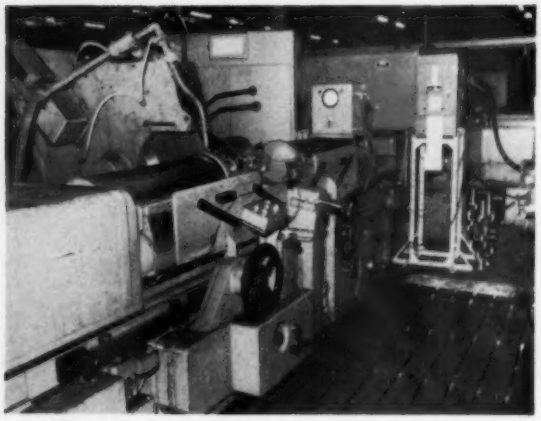
Following three grinding operations on a Newall, a Landis and a Precimax machine, the shaft passes to an Archdale 11-station automatic in-line transfer machine. This machine is designed to drill, countersink and tap holes in the flange; mill a keyway and an oil groove in the stub end; drill and tap a hole in the front end and mill the front end to length; drill, finish bore and chamfer the pilot bearing hole and undercut the flange.

To complete the actual machining operations, the crankpins are finish ground on Newall machines and finally all journals are polished on an Impco polishing machine. Two interesting machines have been installed for finish grinding the crankpins and cheek faces. They are automatic crankpin grinders recently developed by Newall Engineering Co. Ltd., Peterborough, and are the first of their type to be installed in any factory.

These machines are designed with push-button operation to initiate the following cycle. After the shaft is loaded and clamped in position, the push-button is pressed to bring the wheelhead forward at rapid approach rate and to start shaft rotation. Rapid approach continues until the wheel is just clear of the cheek faces; at this point the in-feed slows down



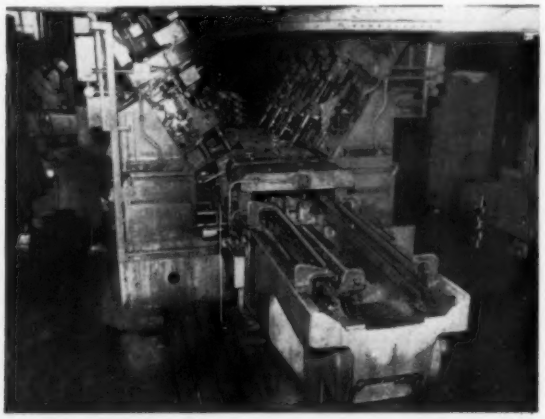
Above: Balancing and mass centring machine for crankshafts developed by the Research Division of General Motors



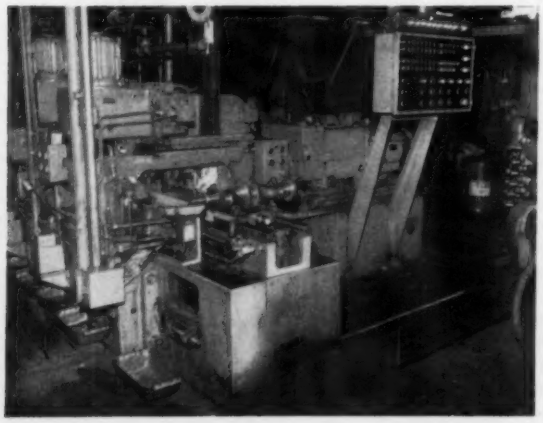
Above: A Newall automatic crankpin grinding machine fitted with Sigmatrol control equipment

Below: The loading end of an Archdale transfer machine for drilling oil holes in the crankshaft

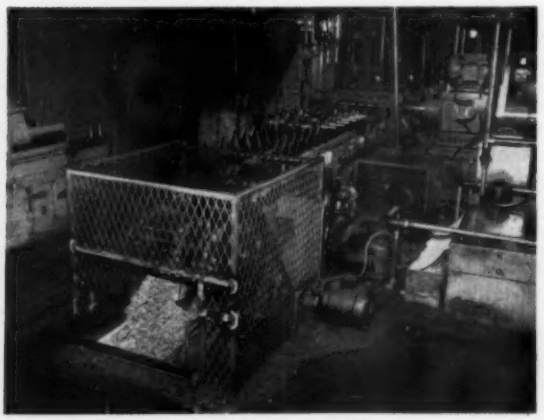
Below: The discharge end of the oil hole drilling machine. The work is automatically ejected

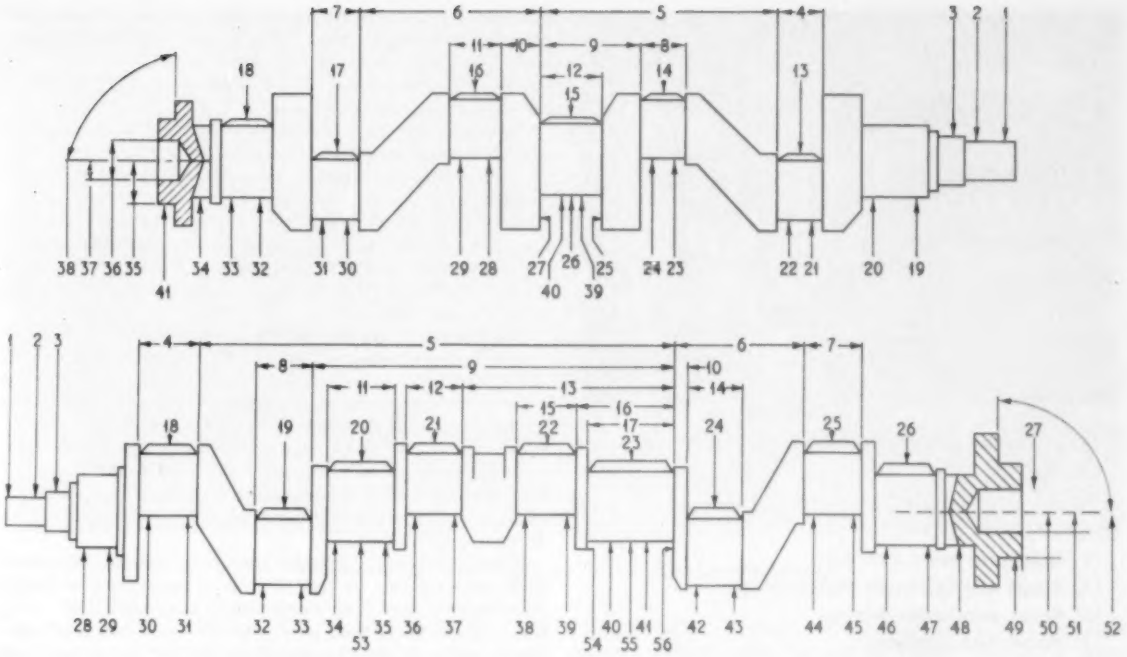


Below: An Archdale transfer machine equipped for drilling, reaming, tapping and milling operations on crankshafts



Below: The discharge end of the Archdale machine. The swarf conveyor can be seen in the foreground





These drawings show the checks taken on four-throw and six-throw crankshafts on the Sigma machine

to a predetermined rate for grinding the faces; when the faces are finished a further roughing feed is automatically applied until a diameter within approximately 0·006 in of finished pin size is reached. At this stage the in-feed rate is automatically reduced to fine feed rate that allows a Sigma air sizing gauge to locate smoothly on the pins, and the machine is automatically stopped when size is reached.

When grinding stops on the first pin, there is automatic rapid withdrawal of the wheelhead, the steady rest and the sizing gauge retract to their stop positions and work rotation ceases. When the wheelhead reaches its rear position, it operates a control circuit that indexes the table to a position relative to the other pin in the same plane as the pin already ground. At final location in the spacing bar, the table-locking plunger engages a micro-switch to start a repetition of the grinding cycle. After the second pin has been ground and the wheelhead has retracted, the table returns automatically to the correct position in relation to the first pin. The automatic cycle can be arrested at any stage by the application of a single push-button.

Safety interlocks are incorporated in the control cycle for the following purposes:

(a) To prevent initiation of the cycle before the workpiece is clamped. This is effected by means of a pressure switch in the hydraulic feed line to the clamps.

(b) To obviate movement of the table unless the workheads are in the correct operational position. A cam, operating a switch mounted on the work spindle, performs this function.

By means of a single rotary switch, the complete automatic cycle can be disengaged, and simultaneously a set of control buttons for manual application during setting-up is brought into operation. The machine is also provided with a hydraulically-operated wheel dresser.

This machine incorporates Sigmatrol control equipment developed by Sigma Instrument Co. Ltd. A Sigma grinding caliper is fitted to the machine and is arranged to move forward with the work steady and to locate on the pin that is being ground. As metal is removed from the pin, a calibrated air valve, mounted in the caliper, causes an electro-pneumatic capsule unit, in a two-stage Sigma controller, to inflate in sympathy with the size of the pin.

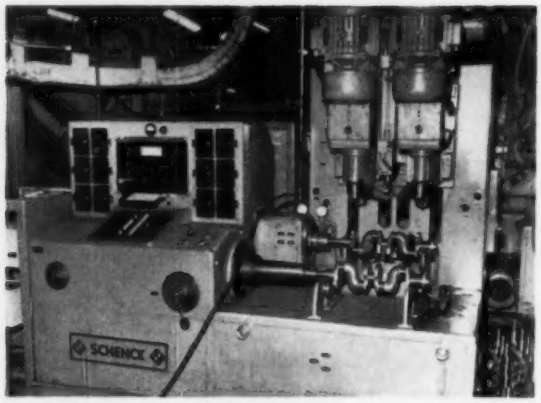
When the pin reaches a predetermined size, electrical contacts in the capsule close and cause an electrical impulse to be submitted to the electrical controls of the machine, thus causing the plunge feed rate to change from rough to fine. The fine feed continues until the pin has been ground to the required size, whereupon the Sigmatrol controller emits a second electrical impulse to the machine, which causes the wheelhead to withdraw and the table to index. Similar control equipment is used on other grinding machines in this section.

This type of automatic machine has several advantages over earlier crankpin grinders. In the first place, since the operation is completely automatic, it will give greater output than a machine that calls for manual indexing. Furthermore, the possibility of errors arising through mistakes by the operator is completely eliminated. In addition, one operator can easily tend two machines.

Following the crankpin grinding, the shaft is balanced and any necessary correction is made. There are two balancing machines for each line, one developed by General Motors and the other a Schenk automatic machine. After the shaft is balanced, the pins and journals are polished on a special Impco machine, from which the shaft passes through a special Dawson washing machine before it reaches the final inspection station.

Crankshaft inspection devices

A number of inspection devices specially developed by Sigma Instrument Co. Ltd., for use in this section play a very important part in quality control. They comprise five inter-operation inspection fixtures and a final fully automatic inspection transfer machine.



A Schenk automatic machine for final balancing of crankshafts

The inter-operation fixtures are used after the following operations in the cycle:

(1) Milling the notch locations
(2) Rough and finish turn main bearings
(3) Rough grind main bearings
(4) Finish turn crankpins
(5) Finish grind main bearings.

These fixtures have been designed to give rapid and accurate dimensional information to ensure that manufacture is kept under strict control. A Liquicolumn Indicator is incorporated in each fixture. This makes it possible for the operator to take a rapid and accurate check immediately after a workpiece has been removed from the machine. This is important, but even more important is the fact that the fixture gives information that indicates whether the manufacturing process is of a stable or unstable character. This is made possible by the Sigma Signal Retainer Units, which is fitted to every Liquicolumn Indicator.

When a component is placed in the inspection fixture, the size of each dimension to be measured is indicated by the height of the liquid in the appropriate tube. By means of the Signal Retaining device it is possible to retain the result of inspection on the indicator panel after the component has been withdrawn. When a second part is inserted in the inspection unit, the section of each of the pneumatic circuits connected to the measuring units takes up a pressure corresponding to the size of the part under measurement, while the portion of the pneumatic circuit incorporating the indicator tubes remains at a pressure corresponding to the size of the part previously measured.

Depression of a pedal causes the whole of the pneumatic circuits to take up pressures corresponding to the dimensions of the part that is in the fixture. As this change takes place, the height of the liquid in each of the indicator tubes moves from the position that indicates the size of the previous part to the position that indicates the size of the part being tested. By observing the magnitude of this movement and its relation to the specified tolerance limits, it is possible to determine the relative difference between the two parts; from this the stability of the manufacturing process can be assessed.

Investigation of a manufacturing process by this technique involves an inspection operation that takes about one minute to disclose the whole of the technical information that would be obtained by plotting and analysing a process control chart for the same process and component—such a chart could easily take up to 90 minutes to construct.

Two very special transfer type inspection machines have been developed by Sigma Instrument Co. Ltd. in close association with Vauxhall Motors Ltd. for the final inspection of machined crankshafts. One is for four-throw shafts and is designed to inspect 41 dimensions; the other is for six-throw shafts and inspects 56 dimensions. The machines are identical in basic principle.

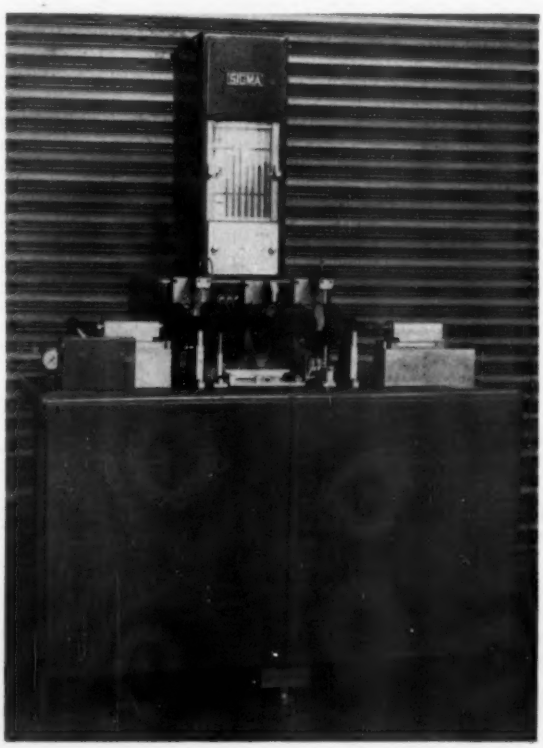
On leaving the Dawson washer at the end of the machine line, the shaft is automatically impulsed into a pair of vees, and a motorized driving unit with a clutch assembly is brought forward into contact with the flange of the crankshaft. This unit rotates the shaft until the crankpins are brought into the correct radial position for the gauging station. To effect this, one pin is brought into contact with a fixed stop, at which point it triggers a micro-switch to indicate correct positioning.

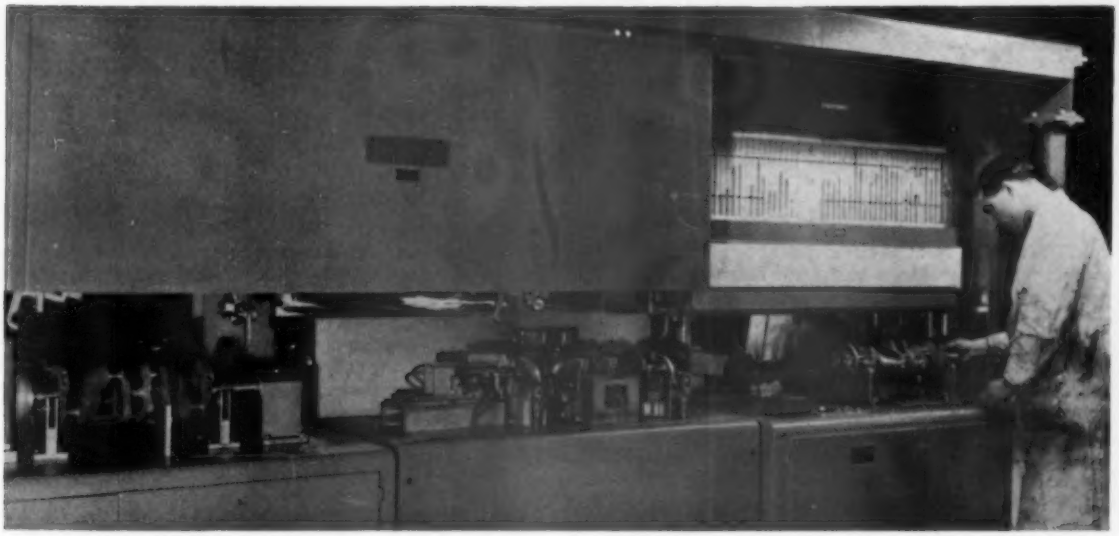
The inspection machine incorporates a moving carriage and a lifting unit consisting of two sets of pneumatically operated claws, mounted on roller slides. In operation the claws descend from the carriage, one set to pick up the shaft in the loading bay, while the other picks up the shaft in the inspection station. The claws then lift the shafts and transfer one from the loading bay to the inspection station and the other from the inspection station to the unloading bay ready for delivery to the assembly, providing, of course, that it is dimensionally correct.

When it is lowered into the inspection station, the crankshaft seals off two air jets when it is correctly positioned. This ensures that if an incompletely machined shaft is by some mischance offered to the machine and does not completely enter the gauging station, the measuring probes used in the static test will not be impulsed; this prevents any danger of serious damage to the measuring heads.

As soon as the shaft is correctly loaded into the machine, the static gauging elements are automatically fed into position and dimensions 1-18 on four-throw shafts and 1-27 on

One of the five Sigma inter-operation inspection fixtures used in the crankshaft inspection section





A Sigma automatic transfer machine for final inspection of crankshafts

six-throw shafts are checked and the results are registered on the Liquicolumn Indicator.

After the static dimensions have been checked, the results are held in the Liquicolumn Indicator. The crankshaft is then rotated slowly to facilitate the inspection of such dimensions as roundness of pins and journals and squareness of flanges. Crankshaft rotation is effected by a motorized unit and the pressure of the drive rollers on a crankshaft flange is effected through a trunnion-mounted pneumatic cylinder arrangement.

For the rotational test, the crankshaft revolves on the outer main journals in two fixed Vee-units. As the shaft rotates, specially designed Vee-units, mounted on a roller slide with counterpoise weights, follow the rotation of the crankpins. Thus, since the measuring air is switched on during the rotation, an infinite number of diametral measurements are taken on every pin and every main journal.

The level of liquid in the indicator unit varies according to changes in diameter and thus a measure of roundness is obtained. As with the static test, the results are shown and retained on the Liquicolumn Indicator Unit. When the rotational check is complete, the crankshaft is automatically stopped with the crankpins in the correct position for withdrawal from the measuring unit.

The shaft is then automatically lifted clear and transferred to the unloading bay, where it is laid in two Vee-blocks to allow a visual inspection for surface defects. While this visual inspection is being carried out, another shaft has been transferred to the gauging unit, the static test has been carried out automatically and the rotational test has started. The results of the static test are retained, and therefore when the inspector has finished the visual inspection of one shaft, he can immediately see the results of the static test on the next shaft and observe the rotational results.

The Indicator Unit is calibrated over a fully linear 10 in scale, and the boundary conditions corresponding to the drawing tolerances on the component are clearly shown. As with the standard Liquicolumn Indicator Unit, it is possible to set the machine without the use of complicated setting masters. Provision is made for zero setting on all dimensions.

A special electro-pneumatic capsule is fitted in each of the measuring circuits. The capsule responds to the differential measuring pressure, that is, to the pressure which causes the liquid in the Indicator Unit to rise or fall when plus or minus measurements are made. If the measured size of the component indicates plus, the capsule inflates because the pressure inside it increases in relation to the pressure outside; similarly, when a minus dimension is indicated, the capsule will deflate. The electrical contact screws are so fitted that as the dimension of the component reaches either the plus or minus boundary condition, a silver contact on the capsule completes an electrical circuit over the adjustable contact screws. This not only completes the circuit to the indicator lights, but also impulses a unit that punches an inspection card in accordance with the dimension found to be incorrect —this is a standard Hollerith card punching unit. A card is delivered with every rejected crankshaft but not with shafts that are acceptable.

Provision has been made in the design for fitting a two-way transfer system in the unload bay. Briefly, the arrangement would be that for an accepted shaft one of the transfer mechanisms would be impulsed to move the shaft automatically towards the assembly line, while a shaft rejected for dimensional inaccuracy would be automatically transferred, together with a punched card, to the re-work section.

HANDBOOK OF STANDARDS

SINCE the book entitled "Standards for the British Automobile Industry" was reviewed in the September, 1957, issue of *Automobile Engineer*, The Society of Motor Manufacturers and Traders, of 148, Piccadilly, London, W.1, has published some additional standards. These, together with a new index for the handbook, are obtainable from the Standards and Technical Department of the Society. The price of the handbook is £4-4-0, with a 50 per cent discount to members of the S.M.M.T., and the cost of having it maintained up-to-date is £1-1-0 per year.

The new standards are under the different headings, as follows: in the section entitled "Non-ferrous metals", there is one new standard, and there are two more under the heading "Non-metallic materials". There are 27 new standards concerning "Instruments and Electrical Equipment". "Lighting and Signalling" is dealt with separately, and there are two new standards in this section. There are also two more under the heading "Trailers", three under the heading "Engine and Chassis", and one more in the "General" section.

The Butterworth Swing Valve

A Novel Inlet Valve for Racing Car Engines. Development Aided by Stroboscopic Study of Operation at High Cyclic Speeds

ALTHOUGH great advances have been made in internal combustion engine design in the last fifty years, the simple poppet valve is still basically unchanged. There have been many attempts to produce a more efficient device to control the flow of gases but, apart from a brief vogue enjoyed by the relatively costly sleeve valve, the supremacy of the poppet valve has never really been challenged. Developments in port design and improvements in valve materials have, indeed, brought very useful increases in specific output, and the advent of desmodromic valve gear offered relief from the difficulties of obtaining consistent spring performance at high speeds. Nevertheless, the obstruction to the gas flow caused inevitably by the straight, axially-moving poppet valve which, with its guide, must traverse the port at some point, is a major factor limiting volumetric efficiency.

A novel design, which appears to provide a practical alternative, has been introduced recently by Butterworth Engineering Co. Ltd., Frimley, Aldershot; Mr. A. J. Butterworth, the principal of the firm, is a specialist in the development of racing car engines. The new device, known as the "swing valve", now has a long period of successful development behind it, and would seem to provide answers to many of the problems associated with the conventional type of poppet valve. The design is patented.

The valve is illustrated in Fig. 1, mounted together with the operating arm and the torsion spring on its rocker shaft, and the assembly of cylinder head and valve gear is shown in section in the line drawing, Fig. 2. The valve head and conical seating are identical with those of a straight poppet valve, but there the resemblance ends. There is no valve guide, the mushroom head being integral with a curved arm which is rigidly mounted on a serrated rocker shaft carried in bearings in the cylinder head. The valve arm is oscillated through an arc, in the same way as a conventional overhead rocker arm, by a tappet and a short push rod engaging a small arm also mounted on the rocker shaft and approximately opposite the valve arm. There is no valve spring in the conventional sense; the valve is closed by a three-element torsion spring assembly attached to both the rocker shaft and the cylinder head. When the valve is lifted the torsion spring twists coaxially with the shaft.

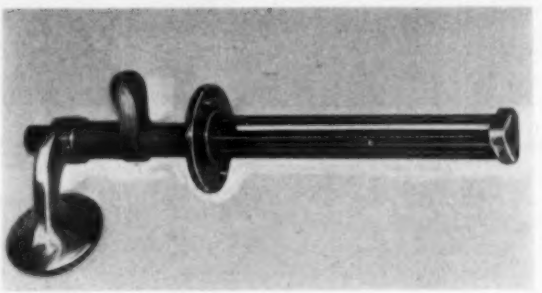


Fig. 1. The Butterworth swing valve mounted on its rocker shaft. At the right of the rocker shaft is the torsion spring assembly which closes the valve

To accommodate the curved arm a rectangular recess is formed in the side of the inlet passage. As the valve lifts to the fully open position, the arm swings into the recess, leaving the entire cross-section of the passage unobstructed

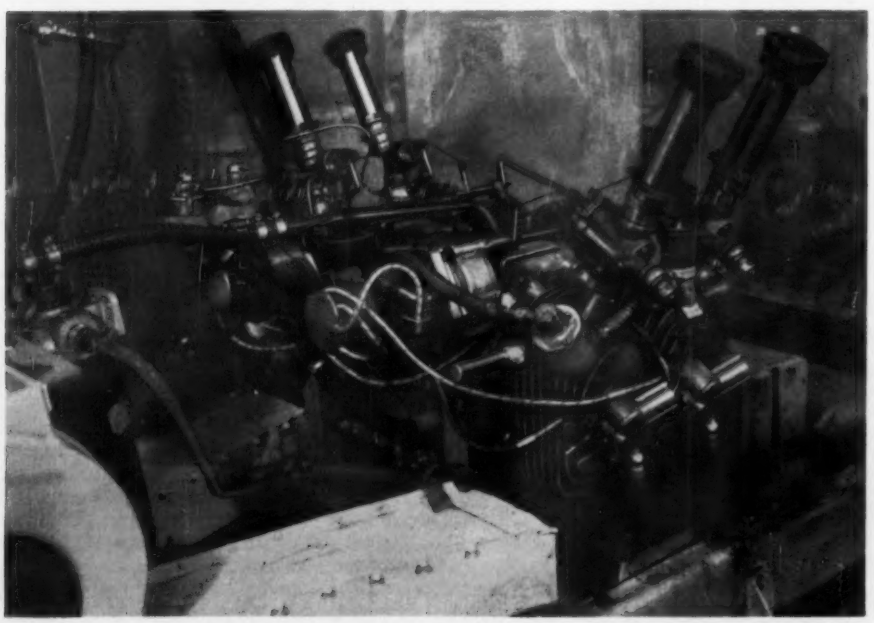


Fig. 3. The A.J.B. 1½-litre Formula II racing engine, incorporating swing inlet valves, on the test bed. The four horizontally opposed cylinders are air-cooled by blast when the unit is installed in a car, and no fan is fitted

apart from a small portion of the arm which is of an approximately streamlined section. The mushroom head itself is carried at an angle into the cylinder space, well clear of the port and allowing an uninterrupted flow of gas. This arrangement eliminates the prime cause of flow restriction, the bulky valve guide, and permits a much straighter inlet passage layout. There remains no need for the induction passage to turn through a sharp angle to provide a point of support for the guide and to avoid the operating gear.

A marked improvement in volumetric efficiency is claimed due to the unusually free breathing which allows a full charge to be drawn into the cylinder on the induction stroke. As yet, the valve has been applied only to the inlet side, where the greater problem arises. On the exhaust side, the hot gases are expelled at comparatively high pressure, which ensures fairly good scavenging. Induction must rely on atmospheric pressure, plus what can be gained in a racing engine from tuned induction pipes.

The development of the valve provides an illustration of the saying "racing improves the breed," for the initial field testing was undertaken in the A.J.B. racing engine for which it was designed. This engine, shown on the test bench in Fig. 3, is itself of unconventional design. It is a horizontally opposed, four-cylinder unit of 1½ litres capacity, to meet the racing Formula II. Although the exhaust valves are of the straight, poppet type, they also are closed by multiple torsion bar springs. It was raced last season with some success in an Elva car, and present plans are to mount a similar unit in a Cooper chassis for the current season. The new valve gear, with its low reciprocating mass and stiff spring assembly, promises to be free from many of the problems of bounce and float which beset the straight valve at very high engine speeds. During the strenuous development programme, however, some difficulties were encountered, the solution of which raised several points of interest.

It will be noticed that the asymmetric valve design would appear to make it impracticable to grind-in the valve on its seating. To overcome this difficulty, the form of construction illustrated at the bottom right of Fig. 4 was first adopted. The valve head of Silchrome material was attached to a separate arm of 100-ton material by a nut tightened down and locked to a shoulder on the valve stem. The length of the shoulder was arranged so as to leave the valve head just

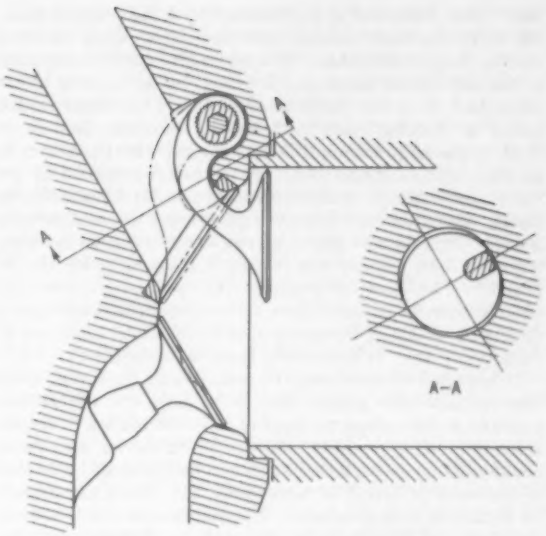


Fig. 2. Sectional view of typical swing valve assembly. Flow of gas through the straight inlet passage is virtually unobstructed when the valve is in the open position

free to rotate for the purpose of grinding in. During high-speed test running, however, it was found that the valve did not remain properly seated when closed, and gas leakage occurred. It was deduced that this was not due to the usual valve bounce encountered on most engines at speeds in excess of the capabilities of the valve springs, nor was it "float" in the conventional sense in which the valve assembly has too much inertia to follow the cam in closing.

Mathematical investigation of the problem did not disclose a likely cause, and it was decided that visual examination was the only way to find a solution. This involved the construction of a special mock-up of one cylinder head, with part of the structure cut away to reveal the valve in operation. The set-up is illustrated in Fig. 5, with the simulated cylinder head at the centre and the operating controls at the extreme

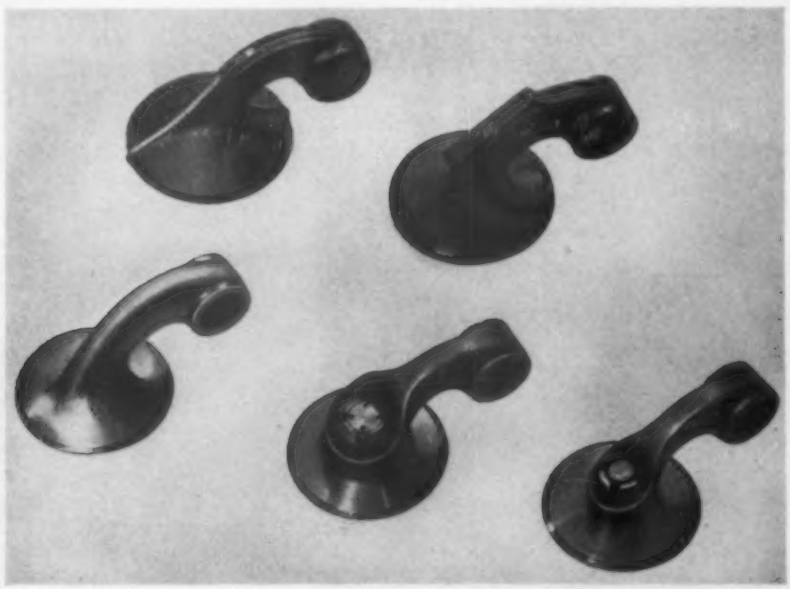


Fig. 4. Evolution of the swing valve. Bottom right: the original two-piece valve. Bottom centre: the strengthened version. Bottom left: the final one-piece design, made from the forging above it. The blank at the top right is an experimental investment casting

left. The crankcase is represented by a rigid metal mass, the barrel has been omitted, and the cylinder head mounted on four long, rigid studs. The camshaft, which is mounted at the top of the structure, is driven by an electric motor controlled from the panel at the left. This shunt-wound motor is "swung" and its torque is recorded directly in lb-ft on the large scale in the background. It thus serves as an input dynamometer recording the power absorbed by the valve gear. Motor speed controls are at the bottom of the panel, with ammeter, oil-pressure gauge, and tachometer above. This rig will run at speeds of up to 12,000 rev/min, which is well beyond the normal maximum speed of the engine. The close-up detail in Fig. 6 illustrates the unobstructed view allowed of the valve in operation, and shows clearly the action of the swing inlet valve, which has a movement of 34 deg. It is not fully open in the picture.

It appeared obvious that the principle of the swing valve was mechanically sound; that is to say, the mechanism performed the actions required of it. Observation at speeds sufficiently slow to enable the eye to follow its movement could yield no useful information and the dynamic behaviour of the valve in action at high speed was, therefore, studied by means of a stroboscope. The instrument used, seen at the right of Fig. 5, is a Strobotorch, manufactured by Dawe Instruments Ltd., 99 Uxbridge Road, London, W.5. This instrument has several features which make it particularly suitable for this kind of high-speed investigation. It has a very brilliant flash, which renders possible its use in the face of quite high ambient lighting, and a flash duration of about 40 microseconds, sufficiently brief to "freeze" virtually any kind of moving mechanism. It incorporates its own speed control, giving flash rates from 120 to 14,000 per minute. The upper limit does not denote the highest cyclic speed that can be studied, as the flash rate can be a submultiple of the operating speed. In normal conditions of background lighting, the actual upper limit is around 100,000 rev/min, which goes well beyond even current gas-turbine speeds. The lamp can also be triggered by the mechanism under study, by means of a contactor unit mounted on a rotating component of the mechanism. By adjusting the contactor, the release of the flash can be arranged to occur at any desired point in the operating cycle, so that the mechanism can be "frozen" in apparent immobility in any position. By using the built-in speed control, the action of any cyclic mechanism can also be studied in slow motion by selecting a flash rate slightly below the repetition rate of the mechanism. With an accuracy of about 5 per cent, the flash-rate control can also be used to measure the speed of a mechanism without imposing any load on it; a technique which has obvious advantages over mechanical methods of tachometry at very high speeds. For greater convenience in handling, the lamp unit (the smaller of the two cases on the bench in Fig. 5) is separate from the control unit and can be held in one hand.

The Strobotorch, operated through its own flash-rate control, was first used for a slow-motion study of the valve operating at high speeds. It was quickly observed that a peculiar floating action was taking place at certain parts of the cycle. To obtain absolute freezing at any required point

Fig. 6. Swing valve shown stationary in the part-open position. Valve and operating arm clear the port, the arm retracting into a recess in the inlet passage wall. The contactor for the stroboscope is at the top

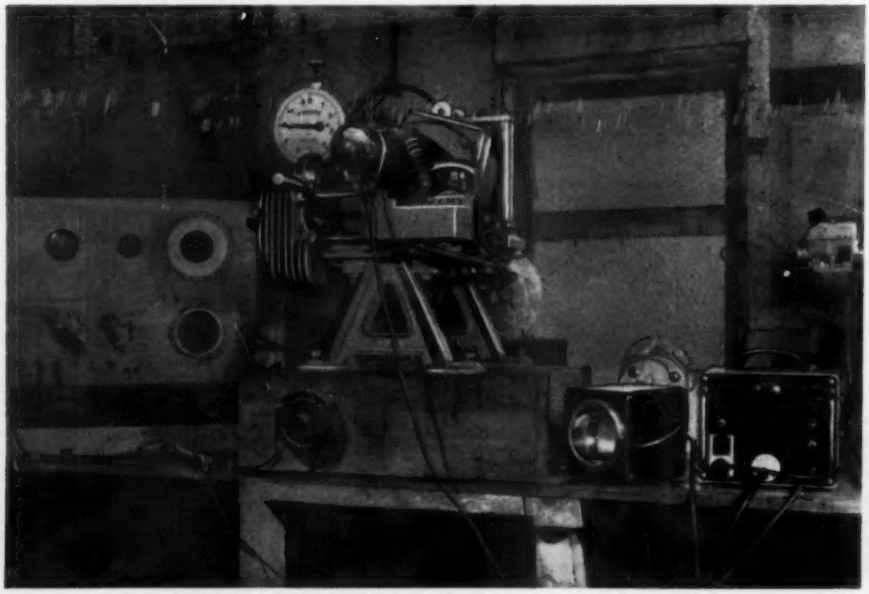


Fig. 5. Test rig for investigating swing valve behaviour under dynamic conditions. The cylinder barrel is omitted to reveal the valve action and the camshaft is driven by an input dynamometer. The control panel is at the left, the Dawe Strobotorch at the right

Fig. 7. Unretouched photograph of swing valve taken by the light of the stroboscope. The valve, operated at the equivalent of 5,500 engine rev/min, is shown in the part-open position. Whip or float would have resulted in a blurred outline

in the cycle, the camshaft was then used to trigger the flash through the contactor unit, which can be seen at the top of Fig. 6, mounted at the front of the camshaft. A phasing device, just visible at the right, moves the contactor relative to the camshaft, so that the valve can be frozen at any point in the cycle, or made to appear to move extremely slowly, by steadily rotating the contactor. The phasing device is mechanically linked with the crankshaft-attitude indicator through a gear train.

Examination revealed that, due to the inertia of the valve head, the arm was whipping with a kind of wave motion. There was a minute, but tangible, time lag between the reversal of the rocker shaft movement and reversal of the valve head movement, due to bending of the valve arm. There was also a certain amount of compression and expansion along the arm as it reversed its motion to open and close the valve. The net result was a combination of "whip" and "float" which, individually or in combination, affected the operation of the valve at certain speeds.

A first, empirical attempt to overcome the trouble took the form of the stronger assembly, as shown at the bottom centre of Fig. 4. Slow motion observation revealed that the greater weight of the arm increased its inertia effect at least as much as its rigidity, so that no gain was noted. It was realized that maximum strength and rigidity could only be combined with good form and light weight in a one-piece design and, after some further experiments, the exceptionally neat design shown at the bottom left of Fig. 4 was developed. The valve, which is ground and polished all over, is made from a forging in HCM 3, shown at top left, Fig. 4, above the finished valve. At the top right is an experimental blank, investment-cast in En 40C steel, which has been discarded in favour of the forging.

Further stroboscopic examination showed that this modification completely solved the problem. The cleaner profile of the arm also allowed a reduction in the size of the recess in the inlet passage into which the arm retracts as the valve is opened. The unretouched photograph in Fig. 7 gives some idea of the clarity of the image provided by the Strobotorch. It was taken at a speed of 5,500 rev/min by the light of the flash, which was timed to occur at a point when the valve was not completely open and still moving at very high speed.

The photograph is, in fact, a composite image of the 229 cycles completed by the valve during the 5 second exposure of the photographic plate. Irregularities in operation, such as whipping or floating, would have caused the valve head to assume slightly different positions in succeeding cycles, which in turn would have resulted in a blurred image. Actually, the outline is completely sharp. An illusion of transparency of the valve head, with the port showing through it, is due to the ambient lighting in the intervals between the flashes. The exhaust valve is almost completely closed. What appears to be an obstruction in front of it, is a gauge to measure the depth of opening and onset of float. Note the twist of the torsion spring controlling the inlet valve, the slight blurring at the near end being due not to movement;

Fig. 8. A.J.B. 1,496 cm³, air-cooled, horizontally opposed, four-cylinder engine, with swing-type inlet valves, installed in an Elva racing car

but to the camera's small depth of field at close range. It is interesting to compare this picture with the conventional photograph in Fig. 6, which was taken with the valve gear stationary.

The expected difficulties of grinding the valve did not materialize. Valve and seat are ground individually to fine limits during manufacture, and appear to bed themselves in perfectly. There is no differential between valve and seat angles; the included angle is 120 deg in each case. With the one-piece design of valve there is, of course, no possibility of valve rotation. However, the controversy regarding rotation or non-rotation has not yet been finally resolved, and experience with the Butterworth swing valve has not revealed any tendency to undue wear or failure to seat effectively. The valve is air-hardened and tempered for 1½ hours at 540 deg C. No failure of any kind has been experienced after extensive test-bench running, and no measurable wear has been detected on the seat surfaces. The austenitic valve seats can be reground or replaced, but this has not yet proved necessary.

The satisfactory result of the stroboscopic investigation has been borne out by bench-testing, in which the normally-aspirated engine of 1,496 cm³ capacity has developed over 150 gross b.h.p. at 7,000 rev/min. Output figures for the engine fitted with straight poppet inlet valves and with swing-type inlet valves, based on the power developed relative to inlet valve-head area, were 14·5 b.h.p./in² and 23·4 b.h.p./in² respectively. For comparison, the highest estimated figure for an existing poppet-valve engine has been quoted as 18·1 b.h.p/in² on the Grand Prix Ferrari unit.

In the A.J.B. design there is no need for the inlet valve to be of considerably larger diameter than the exhaust valve. In the engine illustrated the inlet swing valve and exhaust poppet valve have the same diameter of 1·6 in. Experimental units have been run successfully with inlet valves of smaller diameter than the exhaust valves.

Leakage of gas or air into or through the swing valve gear might be thought to be a possibility, but actually no difficulty was encountered. The valve arm has a clearance of only 0·002 in in the cylinder head recess and the cavity behind it has a volume of only approximately 0·5 cm³. A problem of leakage of oil into the cylinder, however, had to be overcome. This was effected by mounting the rocker shaft in Oilite Superload bearing bushes. These are of the iron-based, self-lubricating type and are drip-fed from the camshaft. They are machined to accommodate an oil seal and have been found to be completely oil-tight.

Exhaust swing valves have not yet been fitted to the engine, but they are under development. The main problem in this case is to overcome thermal difficulties, and the solution is not immediately in sight. It is thought that another one or two years may be required for this purpose. The reason for pursuing this application is that the swing valve occupies less space than the poppet valve and, particularly in racing engines, reductions in size are of prime importance.

To exceed 100 b.h.p. per litre of swept capacity in the current unit, is a most creditable performance, especially from an unconventional air-cooled engine which is still at an early stage in its development. This figure suggests that the swing valve, by making possible a very high volumetric efficiency, may well have a significant future in racing car power units.

Automatic Welding Installation for Axle Casings

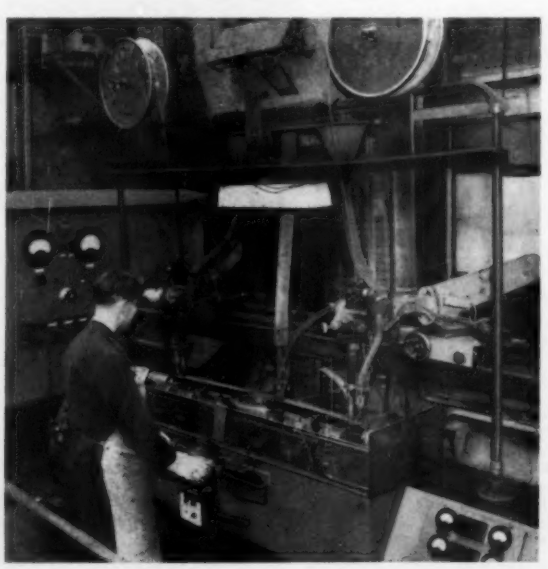
NEW automatic equipment is currently being used for the welding of axle casings at the Birmingham factory of Fisher and Ludlow Ltd. On certain thicknesses of material, the average welding time per casing has been reduced to one-eighth of that required formerly when using manual methods. The equipment, supplied by Quasi-Arc Ltd., Bilston, Staffs, comprises two Unionmelt D.S. automatic welding heads traversable on a track arranged above the work table. These heads are traversed at welding speeds by means of a divided lead screw, each end of which is driven individually by an electric motor. Speed and travel of each head can, therefore, be independently adjusted. Welding current is supplied to the heads from two 750 amp D.C. power packs, each incorporating an auxiliary D.C. generator for supplying power to the lead-screw motor and other control equipment.

Each axle casing consists of pressed halves which are mounted horizontally in a jigging fixture. The halves are secured by air-operated, self-locking clamps which correctly align the pressings and hold them tightly in abutment during the welding operation. The same pneumatic mechanism operates pairs of curved-section metal strips which, when closed, form troughs to hold the Unionmelt welding powder on the weld area. Hoppers mounted overhead hold the powder, which is fed by gravity through flexible hose to the troughs.

It is essential that welding commences at the extreme end of each seam and, therefore, H.F. current is used to initiate the arc. This current is applied by a master switch and is automatically cut off when the arc is struck. The welding heads start from the central aperture of the casing and traverse outwards simultaneously. At the end of each run the heads trip a master switch, cutting off the welding current and energizing a solenoid to lose the gates controlling the flow of welding composition.

Jig clamps are then released and, when the troughs are opened, the melt composition not fused during the welding operation falls into a container for collection and recirculation. While the operator turns over the casing in the fixture, the heads are automatically returned to their starting positions. The operation is then repeated on the other side of the casing.

Unionmelt installation for the automatic welding of axle casings at Fisher and Ludlow Ltd., Birmingham



New Plant and Tools

Recent Developments in Production Equipment

UNTIL recently, three sizes of Lapmaster lapping machines developed by the Crane Packing Company, of Chicago, were manufactured by Payne Products International Ltd., Lawrence Estate, Green Lane, Hounslow, Middlesex. To the "12", "24", and "36" models a new "48" model has been added and is now in production. The designating figure refers to the outer diameter of the lapping plate, in inches. All the now-familiar design features of the smaller models are incorporated in the new machine.

The lapping plate is carried on a vertical spindle mounted in tapered roller bearings and driven by a 7·5 h.p. motor through a flexible, torque-absorbing coupling and a final worm reduction gear. Four "conditioning rings" maintain the lap surface on the lapping plate and serve to retain the work, whether freely seated or positioned in workholders. Pressure plates, resting on the work being lapped, float freely in the conditioning rings. Pneumatic lifting cylinders are provided for all conditioning rings to facilitate loading and unloading.

Lapping compound, contained in a tank on the table of the machine, is maintained at a consistent suspension by a stirring device driven by a 0·5 h.p. motor. A timing clock is set to the desired time cycle. This starts the lapping plate and opens a valve that allows compound to flow down a track to the side of a conditioning ring which spreads it across the face of the plate. At the end of the pre-set lapping time, the clock stops the lapping plate and closes the compound valve. Re-starting is effected merely by re-setting the clock.

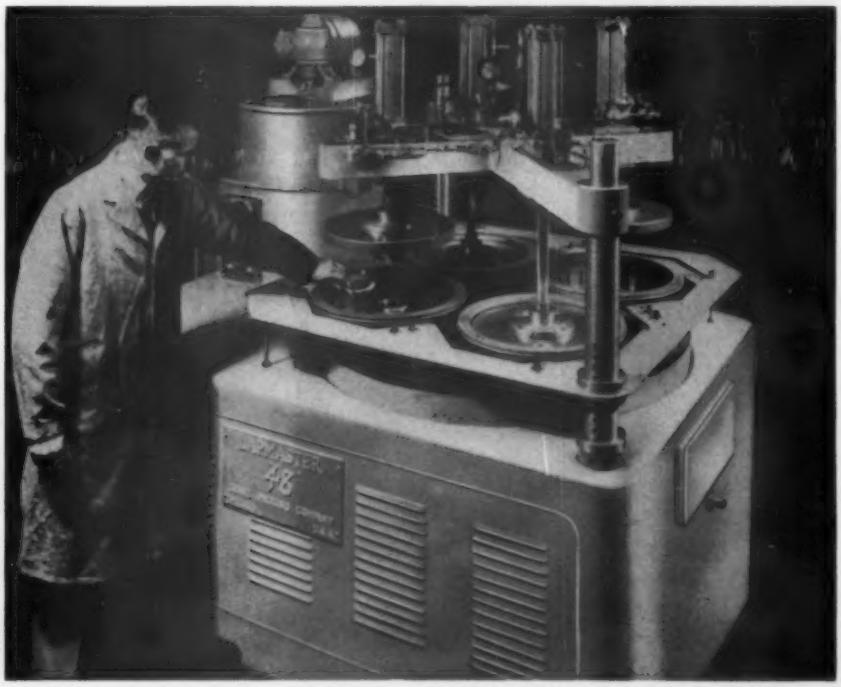
The machine will lap to the extremely close tolerance of one light band (0·0000116 in) and, according to the grade of lapping compound used, produce a surface finish of from 1 to 6 micro-inch. High rates of production are possible. The internal diameter of the conditioning rings is 17 in, and a typical example is four large cast iron gear cases lapped on a joint face in a cycle time of 5 min. In the same time cycle, 944 parts each 1·0 in diameter or 32,720 parts each 0·125 in diameter (actually electrical contacts) can be lapped.

Length and depth indicator for lathes

To machine work to accurate length or depth in a longitudinal direction presents problems on the ordinary lathe. It necessitates the use of various measuring instruments—micrometers, depth micrometers, vernier gauges, slip gauges—and involves repeated stopping of the machine for checking purposes. With the Ceewrite indicator attachment, designed and manufactured in the U.S.A., it is possible to obtain directly any number of lengths and depths, over the whole working length of the lead screw, to within limits of 0·001 in. No time is lost in stopping the machine for checks.

The method of attachment will, of course, vary according to the type of lathe to which it is fitted. A common method is to mount the indicator on the saddle so that it will operate from the lead screw. This method has been used, for example, on the Herbert "Edgwick" lathe.

Operation is simple. The lathe tool is applied to the work and a facing cut is taken if necessary. Indicator dials are set at zero, and any longitudinal movement of the tool can then be read directly from the dials. If required, the dials can then be re-set to zero.



The Lapmaster "48" lapping machine can handle workpieces up to 17 in diameter
Payne Products International Ltd.

The Ceewrite indicator for lathes gives direct reading of longitudinal tool movements to limits of 0·001 in

Alfred Herbert Ltd.

Ceewrite indicators are manufactured in eight models, with either fractional or decimal dials and with various settings. They are marketed throughout the world exclusively by Alfred Herbert Ltd., Small Tools Department, Edgwick Works, Coventry.

Centring attachment

With this Swiss-manufactured HSR Centri-Vite attachment, centring operations can be performed economically on production machines and the need for special, separate-operation centring machines is obviated. It is designed for use on centre, capstan, and turret lathes, when the respective tailstock sleeve or the turret slide is locked. The cast steel body has a taper shank and is fitted with a hardened and ground sliding spindle. This spindle is cut with a side rack and a lower keyway, and is bored to receive interchangeable collets selected to suit the diameter of the centre drill. The collets available range from $\frac{3}{32}$ in diameter to $\frac{1}{2}$ in diameter, and are tightened by a cap nut.

To advance the spindle, a pinion engaging the rack is operated by a hand lever which can be inserted in any desired angular position. A hardened pin on the top of the spindle abuts a stop screw secured adjustably in the upper slot of the body to limit the spindle movement. This maintains a consistent depth of centring and provides for the precise axial location of the workpiece as required. for example, in copy turning from a master.

The feed is, of course, sensitive and thus tends to ensure clean, accurately formed, centre holes and to minimize drill breakages. Centri-Vite attachments are distributed by Insley Industrial Supply Co. Ltd., 21-22 Poland Street, London, W.1.

Mistless spray gun

The use of oil spray guns on assembly lines, for applying die lubricant in the press shop, or for component cleaning and chassis lubrication in vehicle maintenance departments, is liable to cause some inconvenience on account of misting. This may result in an objectionable contamination of the atmosphere and the oil, temporarily held in suspension, may settle as a film on wall, floors, machines and adjacent equipment. The K-L Mistless spray gun, manufactured in Germany, was designed specifically to obviate this disadvantage and is already in widespread use in Europe. Illustrated is the gun for use with a pressurized bulk feed; another model, suitable for small workshops of for garages, has an attached oil container having a capacity of 1·5 pt.

An atomizer of the vortex chamber type is screwed into a holder, termed the jet head, mounted on the end of the gun oil barrel and is fitted with an adjustable, but non-detachable, nozzle cap. The jet head is formed internally with an annular chamber and, to the rear, an enlarged bore in which is supported a concentric tube surrounding the oil barrel. Air at operating pressure passes down the annular space between the barrel and the tube to the jet head chamber and is delivered, by way of a ring of forwardly directed jets, to surround and entrain the oil spray issuing from the nozzle. An adjustable reducing valve at the air intake enables the operating pressure to be regulated to any value up to 175 lb/in², to suit the grade of oil used and the prevailing temperature. Should a higher pressure be required if using specially viscous oils, or if the gun is used for applying undersealing compounds, the reducing valve can be removed.

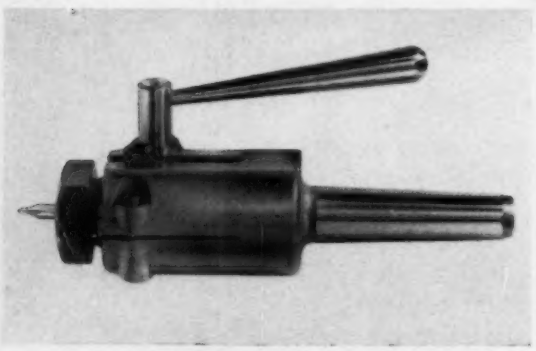
Trigger operation is two-staged. Initial movement opens the air valve only and the gun serves merely as a blow gun to remove dust or dirt from the work. Further movement opens the oil valve and the oil leaves the gun under pressure from the spray nozzle. Both models of the Mistless gun are distributed by Key-Leather Co. Ltd., 5 Urswick Road, London, E.9.

Automatic-cycle milling machines

Simplicity in setting up and in operation are the outstanding features of the two Victoria production milling

HSR Centri-Vite sensitive centring attachment for centre, capstan and turret lathes

Insley Industrial Supply Co. Ltd.



K-L Mistless oil spray gun for pressurized bulk feed. A self-contained tank model is also available

Key-Leather Co. Ltd.

machines, manufactured by B. Elliott and Co. Ltd., Victoria Works, Willesden, London, N.W.10. Both can be arranged for automatic two-way milling on a continuous pendulum cycle, and can be used for the machining of small and medium-sized components rapidly and economically on either short or long runs. The recently introduced smaller machine, illustrated, is termed the Victomatic 0-18" and has a worktable 36 in × 10⅞ in with a longitudinal traverse of 18 in powered by a ¾ h.p. motor running at 1,500 rev/min. Cross traverse of 7 in and vertical range of 14¼ in are manually operated. Sixteen rates of table feed are provided and machines are supplied either with a standard range of from 0·6 in/min to 16 in/min or an optional high range of from 1·3 in/min to 32 in/min. The feeds are changed by means of simple pick-off gears. Quick traverse is at 150 in/min.

The spindle, with a No. 40 taper, is driven by an enclosed 2½ h.p. motor running at 1,500 rev/min, through multiple vee belts to the constant speed shaft. A slidable overarm carries a support for a 1 in diameter arbor, the maximum distance from support to column face being 13⅜ in. Maximum distance from spindle centre to worktable is 18 in.

On the automatic control panel a rotary switch selects the continuous pendulum cycle, a single cycle to the left, or a single cycle to the right. A push button is depressed to override the safety stop in the central position during pendulum cycles. To permit climb milling at either end of the table, a backlash eliminator operating on the leadscrew nut is provided. This enables either right-hand or left-hand cutters to be used. The device is automatically disengaged on the reversal of the table, and a neutral position is provided for use when conventional milling only is being performed.

Oscillating-head tool grinder

Accuracy in the finish grinding of tungsten carbide tools is a factor contributing to long useful life between regrinds. The ease and speed with which accuracy can be obtained, even by an unskilled operator, are important features of the Neven G.F.O. bench-type grinder manufactured by Impregnated Diamond Products Ltd., Tuffley Crescent, Gloucester. The oscillating head of this machine enables the tool to be held stationary on the table while the 6 in diameter wheel passes to and fro across the tool face to produce a perfectly straight edge at any desired rake. This method gives uniform wheel wear and materially extends the periods between re-dressing. An increase in diamond wheel life up to 30 per cent has been quoted.

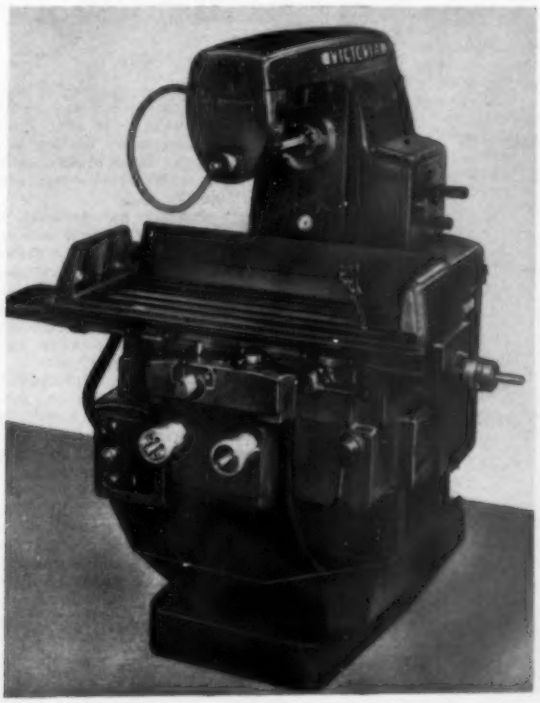
A fractional h.p. motor, having a torque of 30 lb-in and driving through a variable-throw crank mechanism, provides the oscillating motion at a rate of 30 strokes per minute. The stroke length is adjustable up to ⅛ in on each side of centre and the motion can be cut out if curved surfaces, such as nose radii, are to be ground. The main motor develops 1 h.p. at 2,850 rev/min and drives the wheel direct. Tools of either hand can be lapped as the motor is reversible and the wheel guard can be thrown over to give access and to restrict spray on either side.

As standard, the machine is supplied with a Neven medium 120/160 impregnated wheel, but the construction and the method of operation make it particularly suitable for the use of superfine grade wheels. A mirror-finish—approximately ½ micro-inch—can be obtained on a carbide tool tip much more rapidly than on a conventional lapping machine.

Serving as a coolant tank of 2 gal capacity, the heavy, rigid base supports a hinged table with a scaled adjustment for rake from +5 deg to —15 deg. A tenon slot in the table enables a protractor to be used so that angles can be set in both planes. Although built as a bench machine, it can be mounted on a robust, 2 ft 8 in high tool cabinet, as shown in the illustration.

Victomatic 0-18" production milling machine equipped for continuous pendulum cycles and climb milling in either direction

Wickman Ltd.



Neven G.F.O. oscillating-head, diamond-wheel machine for grinding and lapping tungsten carbide tools

Wickman Ltd.

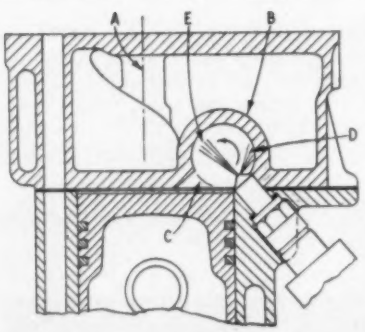
CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Diesel engine turbulence chamber

In this design the combustion chamber is arranged wholly in the cylinder head so that a piston with a flat crown can be used and undue thermal stressing of the crown thereby avoided. Inlet and exhaust valves are mounted in a longitudinal vertical plane A and the chamber B is laterally disposed above the cylinder bore. The chamber is in communication with the cylinder by way of a constricted passage C which opens substantially tangentially into the chamber. Preferably, the atomizer is mounted at an angle in the cylinder block and discharges into the chamber from below and directly behind the mouth of passage C.

A two-jet nozzle is fitted. Jet D sprays a substantial portion of the fuel charge in the direction of the air swirl and at an acute angle to the chamber wall which, locally, it covers with a thin film. This liquid film



No. 774941

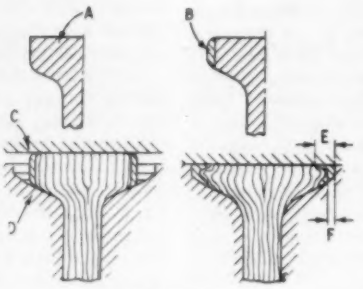
is wholly or partially vaporized and distributed throughout the chamber by the air flow. The area where the jet impinges is, with the rest of the chamber, cooled by the usual circulating system but, if desired, an insert completely or partially insulated from the chamber wall may be provided. Such an insert serves as a hot body during operation and, furthermore, may be electrically heated to facilitate starting in cold temperatures.

The other jet, E, is axially directed to the more remote part of the chamber wall opposite the nozzle, where the air is likely to be richer in oxygen. Further jets may be provided if required, or jets D and E may be combined to form a single wide, flat, spray pattern. *Patent No.* 774941. *Daimler-Benz A.G.* (*Germany*).

Hard-faced valves

In this process for the production of valves with hard metal faces, the head of the blank is of substantially smaller diameter and greater depth than the finished valve head. The periphery of the blank head A is turned or ground parallel to the valve axis and over this machined surface is fitted a ring B of the reinforcing material.

This assembly is then inserted in a two-part die for pressing to its final form.



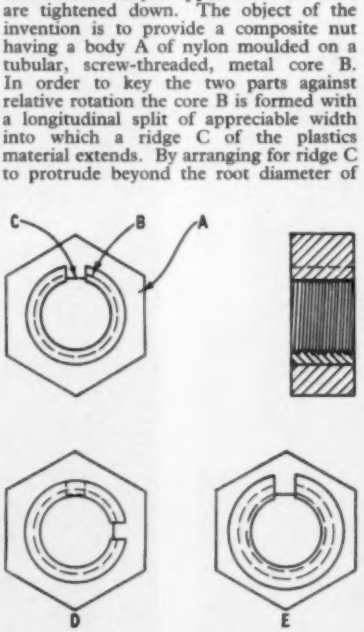
No. 773695

As parts C and D move together axially, friction between part C and the upper face of ring B and between part D and the lower face of the ring restricts the radial movement of the reinforcing material at those surfaces. As a consequence, in the final form of the head the reinforcing material at the upper and lower surfaces has a radial width E greater than the width F at the mid-point of its depth. *Patent No.* 773695. *H. Teves and E. A. Teves—Alfred Teves Maschinen-und Armaturenfabrik K.G.* (*Germany*).

Self-locking nylon nut

While nuts of nylon and similar plastics material possess adequate strength and toughness for numerous useful applications, they lack sufficient strength in shear to resist substantial loads. Consequently, the threads are easily stripped when the nuts are tightened down. The object of the invention is to provide a composite nut having a body A of nylon moulded on a tubular, screw-threaded, metal core B. In order to key the two parts against relative rotation the core B is formed with a longitudinal split of appreciable width into which a ridge C of the plastics material extends. By arranging for ridge C to protrude beyond the root diameter of the threads, this feature is exploited to give the nut a self-locking characteristic.

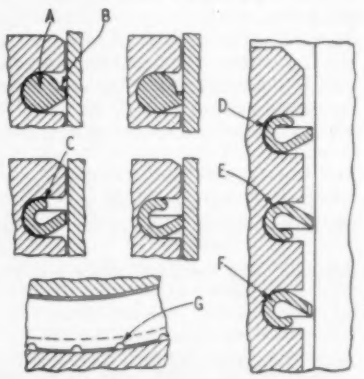
If the core B has a cylindrical outer surface it would be possible to withdraw it from the body A if loaded beyond a certain value. To prevent this, the longitudinal split may be in two parts angularly offset and connected by a circumferential split, or be of helical shape instead of straight, as indicated at D. Alternatively, the core may be formed with external flanges at each end, as shown at E. *Patent No.* 775608. *American Screw Co.* (*U.S.A.*).



No. 775608

Piston ring

While the gas cushion at the back of a conventional piston ring influences the bearing of the ring against the cylinder wall, the magnitude of this force is dependent on the necessary clearance of the ring in its groove. As the piston runs over dead centres the ring changes its bearing between upper and lower flanks of the groove and momentarily combustion gases can pass freely around the ring.



No. 774032

In this new ring the gas pressure is utilized to improve the sealing action. Considered in section taken at a radial plane, the ring has a substantially circular solid or hollow body and an integral, projecting sealing flange. Under gas pressure the ring is resiliently deformed by twisting of the body portion about its axis in the correspondingly shaped groove.

The illustration shows a solid ring A having a troughed flange B, the end face of which effects the seal with the cylinder wall. Left-hand and right-hand views show the ring in relaxed and operative conditions respectively. A hollow ring C is shown under similar conditions.

To seal against pressure in both directions, as in a crankcase-compressing, two-stroke engine, or in a compressor, the individual rings D and E are arranged with their flanges directed in opposite directions. A lower ring F, directed towards the crankcase, is grooved on the periphery of the flange, as at G, so that the scraping edge is interrupted and oil can reach the rings above. *Patent No.* 774032. *Goetzewerke Friedrich Goetze A.G.* (*Germany*).

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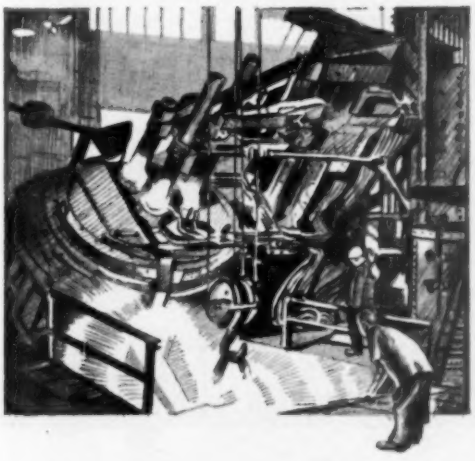

OSBORN

OSBORN FINE STEELS

Tool steels, stainless steels, heat-resisting steels, manganese steels and a wide range of alloy steels are produced by Samuel Osborn & Co., Limited. The reputation of these steels, including the well-known brands of *Hand & Heart, Titanic, Mushet, Tropic and Titan*, depends upon their quality and their quality depends upon rigid control in manufacture.

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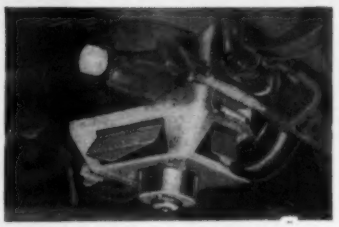
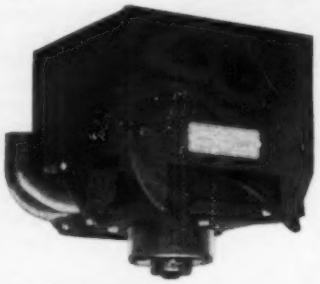
A few of our products are illustrated. When you are next in the market for an exclusive model to fit either as standard or optional extra equipment why not contact us? We shall be glad to submit designs and prices.

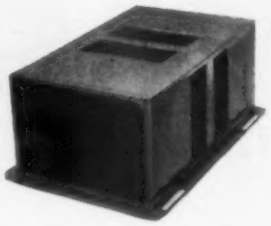


The 'Delanair.' A fresh air heater with fully automatic control.

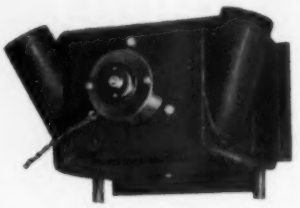
The 'Avialex.' A combustion heater for all types of vehicles.



The 'Good Companion' A recirculating heater.



The '2-in-1.' A recirculating or fresh air heater for buses and coaches.



The 'G.10.' A recirculating or fresh air heater for commercial vehicles.

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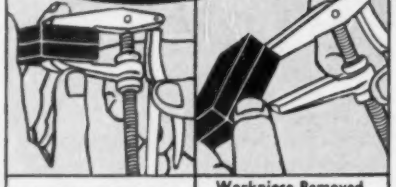
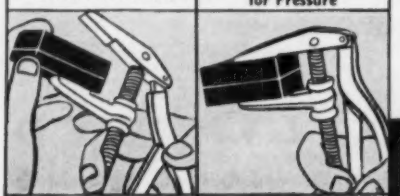
TOGGLE ACTION 'C' CLAMP



Lower Jaw Adjusted to Correct Distance

Workpiece Removed, Lower Jaw Adjusted for Pressure

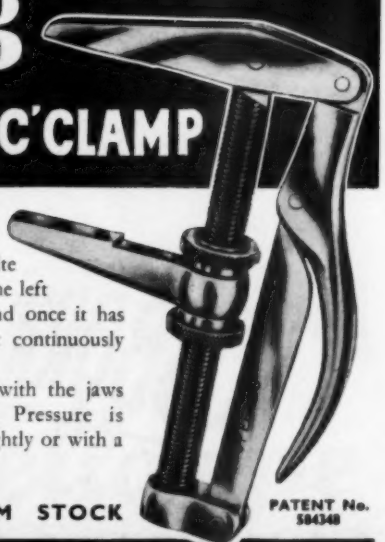


Jaws Opened by Trigger Handle to Insert Workpiece

Trigger Handle now Locks Jaws on Workpiece

The Speetog Toggle "C" Clamp is a self-locking tool which locks on to the work and holds it firmly gripped after quite simple adjustment. The illustrations at the left show how simple it is to set the tool and once it has been set to a definite size it will repeat continuously with the same pressure.

The tool will grip up to $3\frac{1}{2}$" capacity, with the jaws parallel at all points of adjustment. Pressure is adjustable, so that the Clamp will grip lightly or with a heavy pressure as required.



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assembly lubricants that "stay put"

On motor-car engines—and other mechanical equipment—oil films tend to run from bearing surfaces during the period of immobility between assembly and running-in. A **'dag'** dispersion of colloidal graphite applied initially provides all bearing surfaces with a protective graphite film which will "stay put" during the critical starting-up and running-in stages.

Illustration shows ***'dag'*** *colloidal graphite being applied during engine-assembly at the works of the Standard Motor Co. Ltd., Coventry.*

dag
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colloidal graphite

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Lower oil consumption smoother running with DUAFLEX Oil Control Rings

This model 'O' Bedford, operated by Pease Transport Limited (Carriers for Tate & Lyle Limited), was fitted with Duaflex Rings when oil consumption was 1 pint in 88 miles. After fitting, the oil consumption fell to 1 pint in 405 miles and 56,000 miles were completed on this set of rings before oil consumption again rose to a prohibitive figure. This efficient Transport Organisation has equipped many other vehicles of different makes with Wellworthy Duaflex Rings and it is well satisfied with the general improvement in engine efficiency.

Duaflex Rings restore power and efficiency

More and more fleet owners are fitting Duaflex Rings in worn engines using an excessive amount of oil but not yet due for a major overhaul. Self-adjusting Duaflex Rings take up irregularities in the bore and form a gas-tight seal between pistons and cylinder walls, thus reducing oil consumption and restoring lost compression.

How Duaflex Rings work

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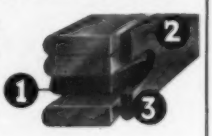
2 The expander maintains an even outward pressure on cylinder walls.

3 The rails 'wipe' oil from cylinder walls, avoid scraping and wear.



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REDUCE OIL CONSUMPTION
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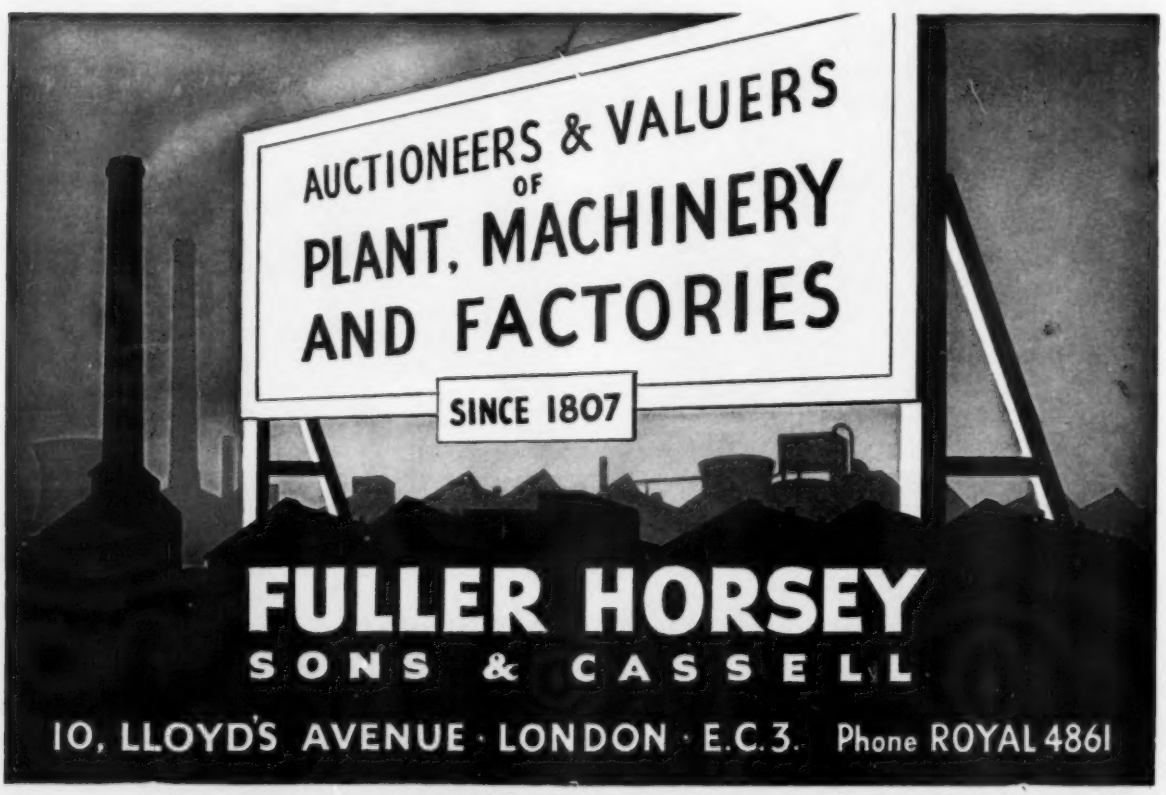
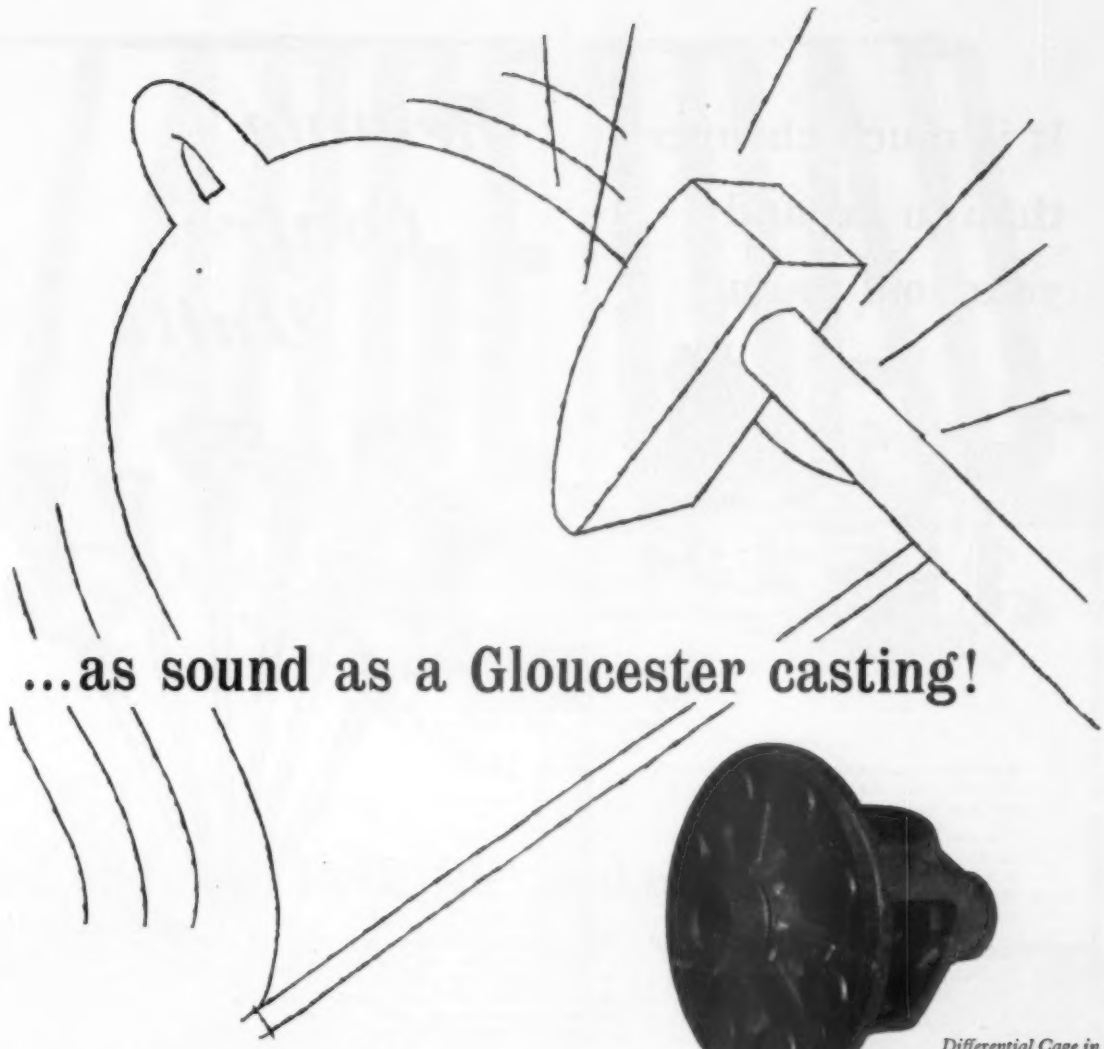


Rathbone



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Differential Cage in Malleable Iron. Weight 8¼ lbs.

"As sound as a Gloucester Malleable casting" is no mere phrase. It is the result of a wealth of traditional skill and technical knowledge at every stage of production. Raw materials, melting and pouring processes, sand practice, moulding and core making, fettling and setting, all are exactly controlled to ensure castings that will measure up to to-day's exact engineering needs.

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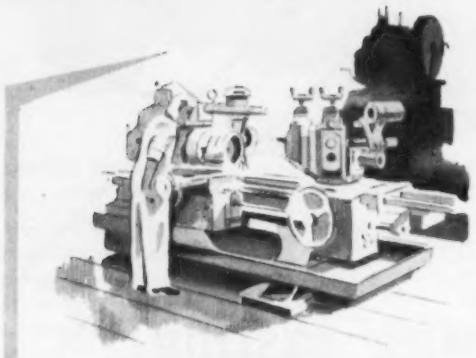

Extra floor space, extra tools mean the expenditure of much capital—and once spent, your capital is tied-up for many years.

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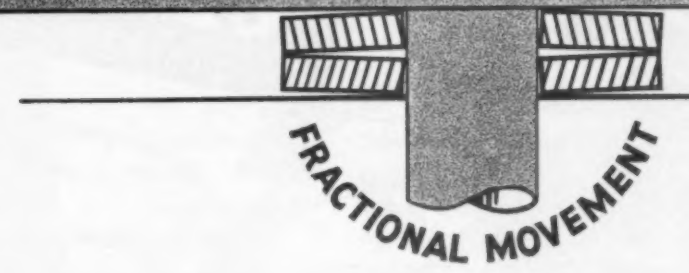

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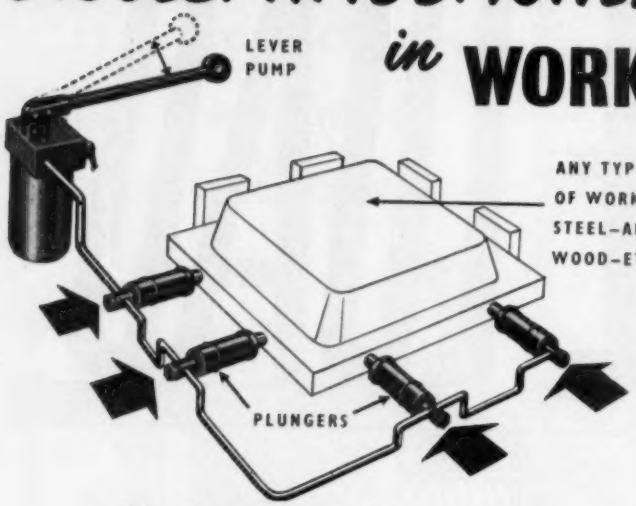

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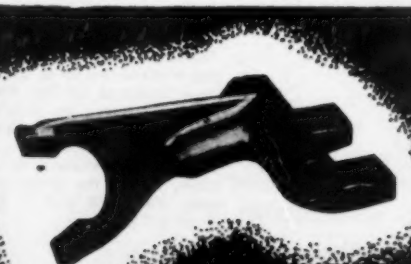

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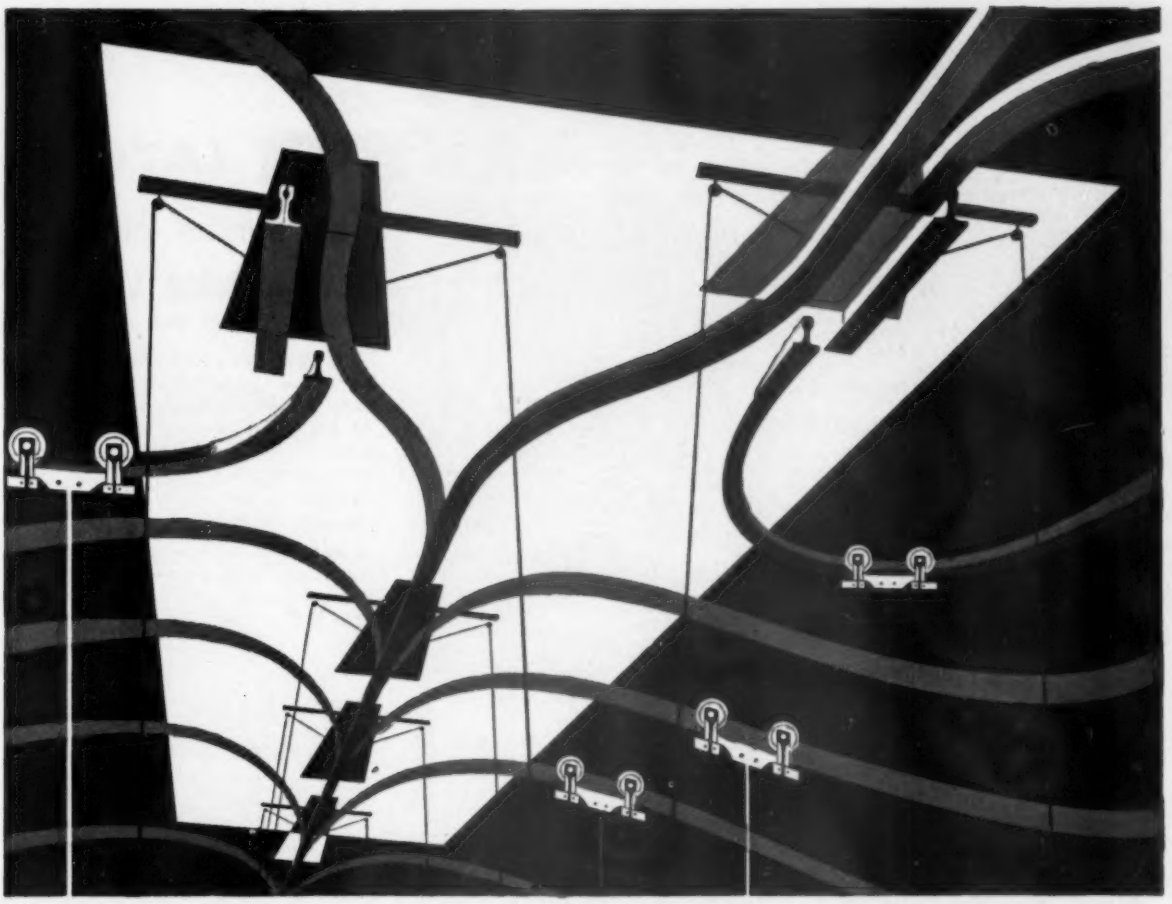

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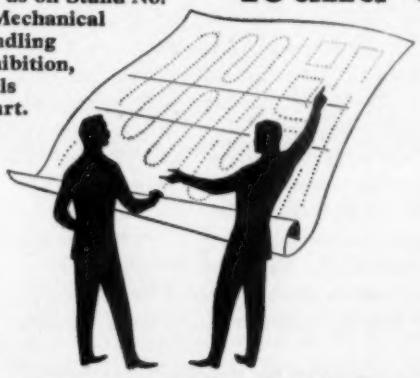

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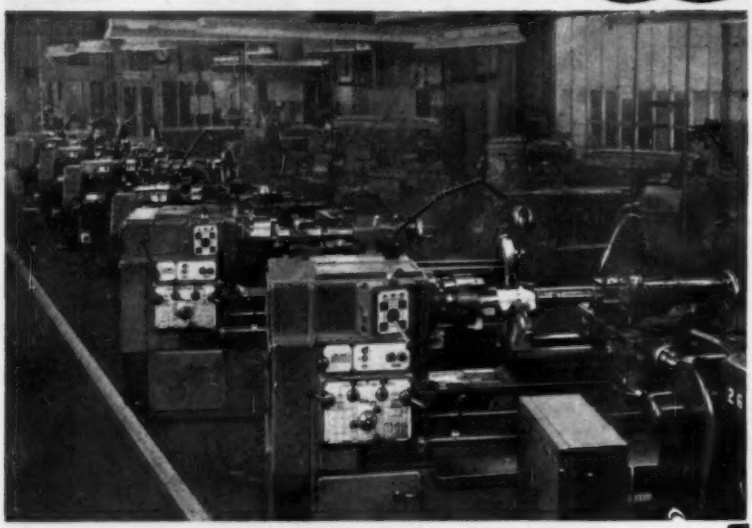

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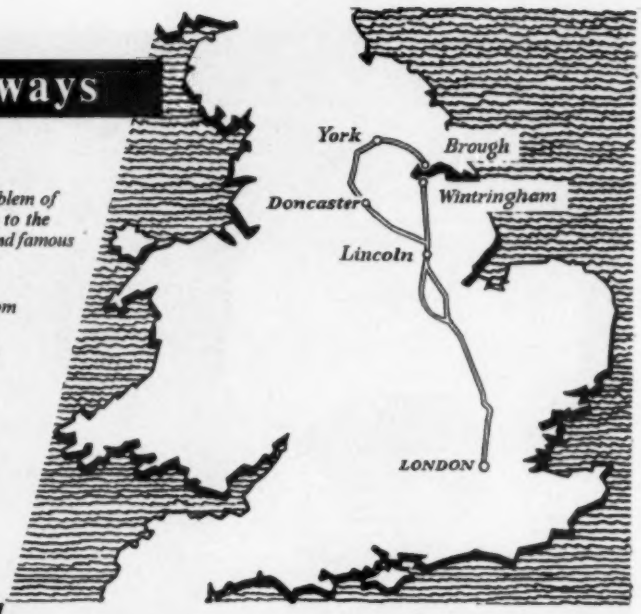
Ermine Street, the third of the Four Ways, was a direct road from London to Lincoln and on to Wintringham on the Humber. By means of a ferry it made communication with Brough and York. North of Lincoln another road diverged from it Westwards to Doncaster. Near London the Enfield Highway is part of the old road.

In Lincolnshire, Ermine Street is known as a 'ramper' or 'The Old Street.' Like Watling Street and the Fosse Way, Ermine Street appears to have been paved from end to end.

Today the historic highway has become part of the main road transport system of the country. This system is about to be modernized so that the transport of the country may continue to flow evenly.



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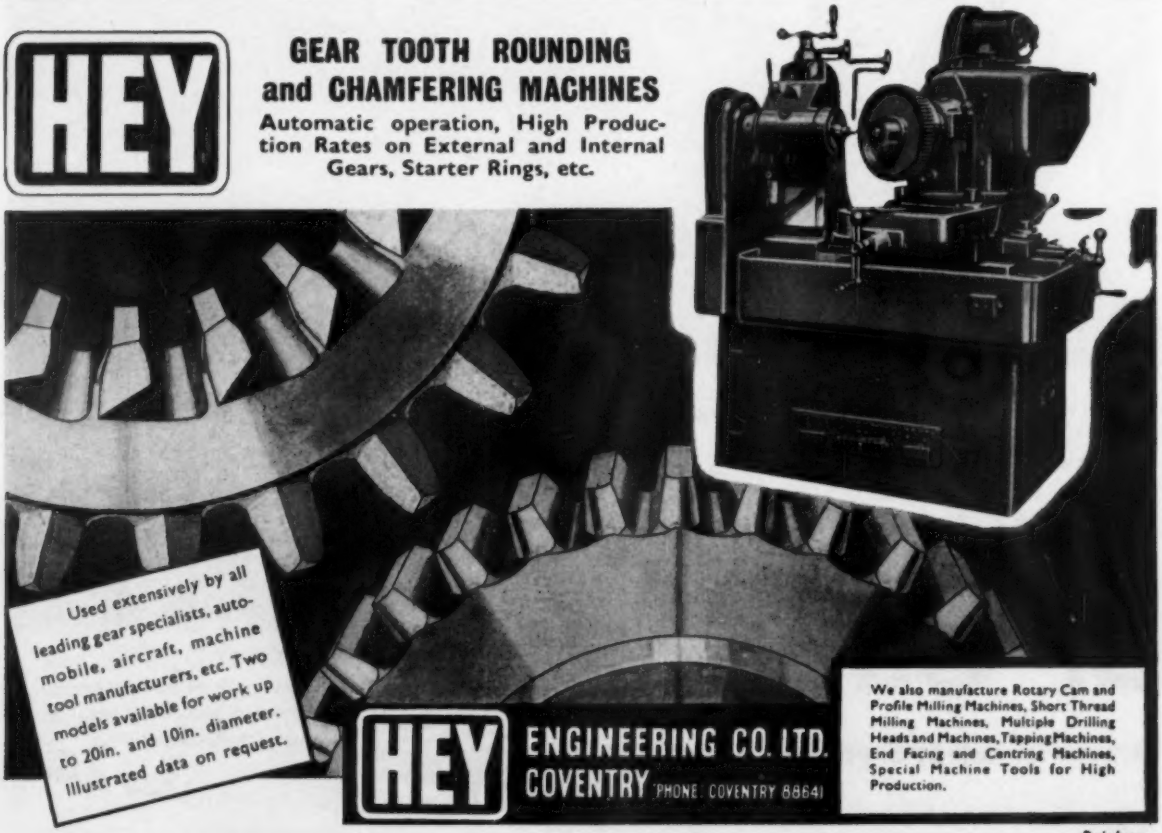

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Rainbow

Remember the first Transatlantic Flight?

The veteran "Greenwell" compressor

This historic photograph marks one of man's most remarkable triumphs—the first ever air crossing of the Atlantic. Alcock and Brown's frail machine lies at a crazy angle in the Irish bog where they landed after their sensational flight. That was in 1919—the year when a "BROOMWADE" Stationary Air Compressor started work for T. W. Greenwell & Co. Ltd., of Sunderland. This compressor gave more than thirty years' reliable service before being replaced in 1949—a wonderful record!

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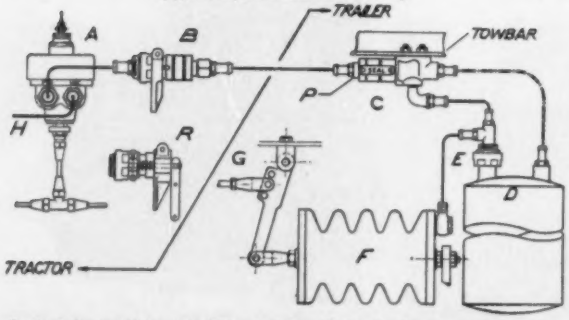

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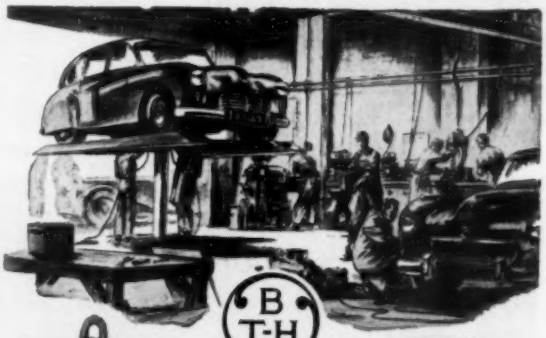

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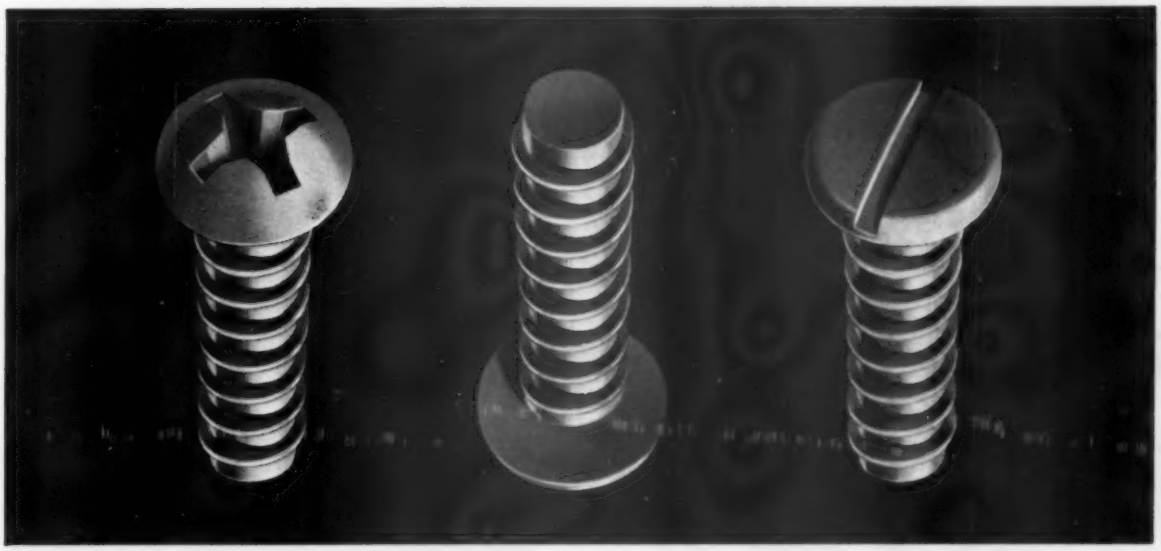
Important announcement to users of Simmonds Spire Speed Nuts



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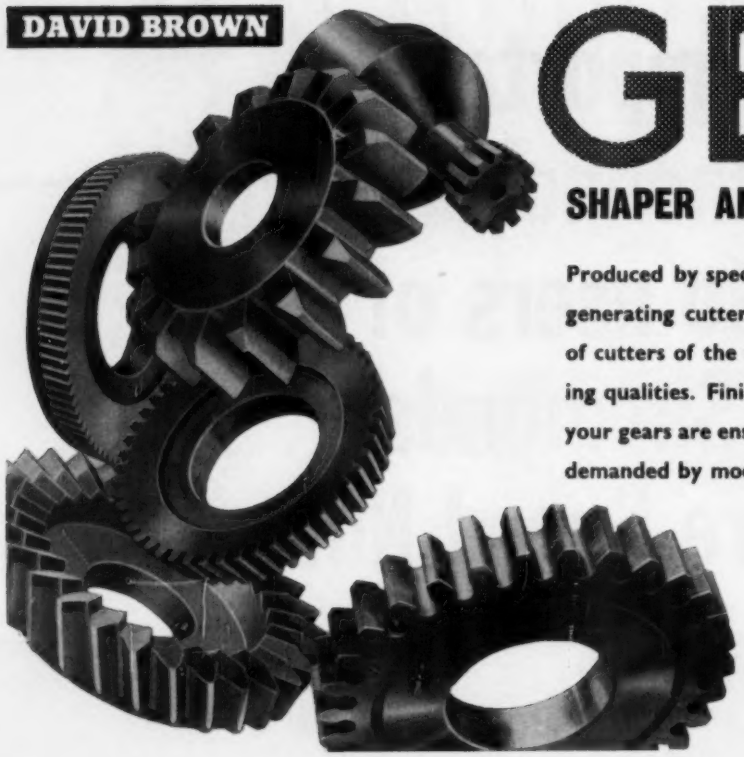

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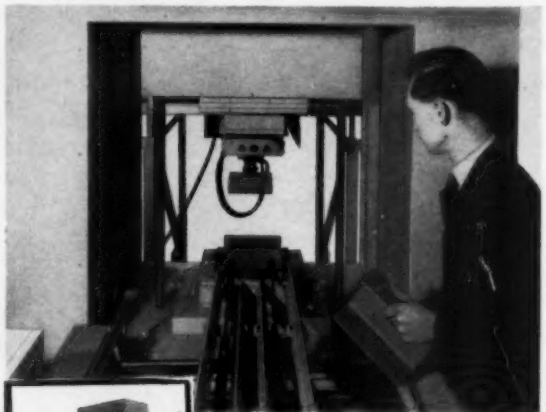

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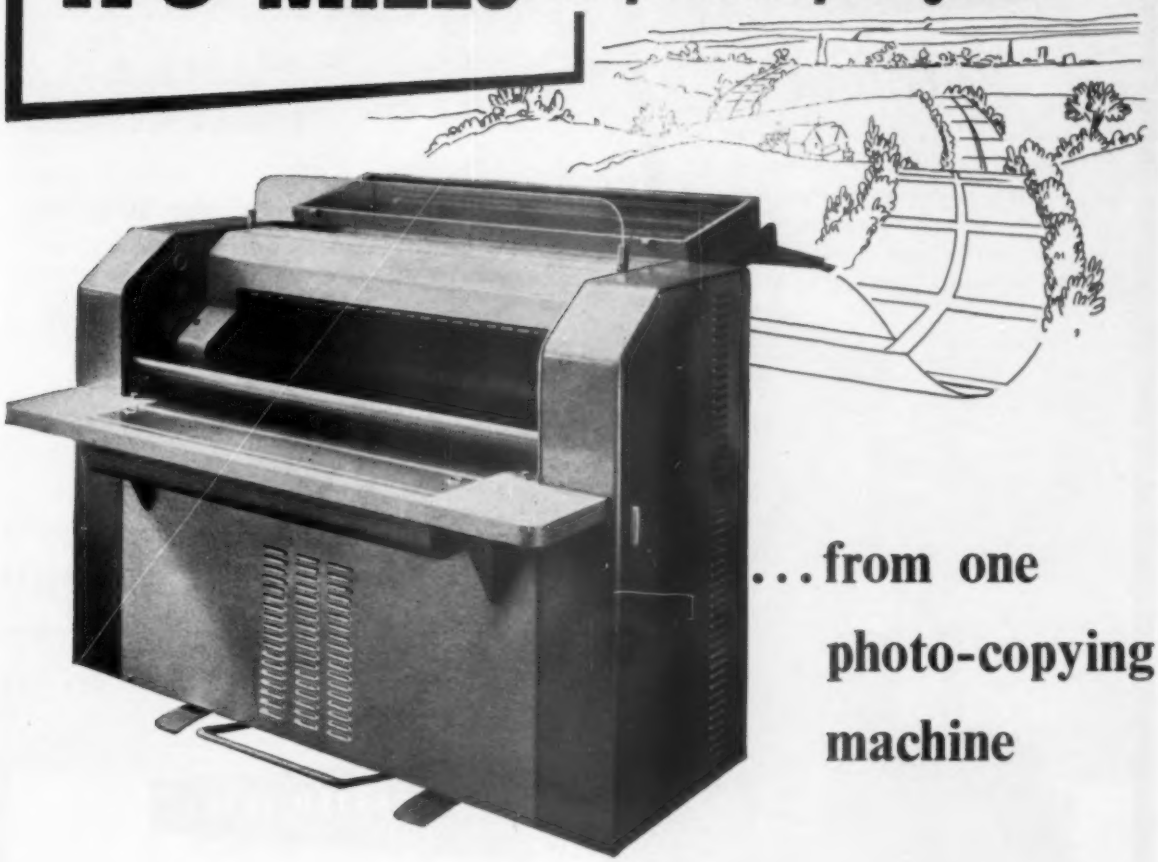

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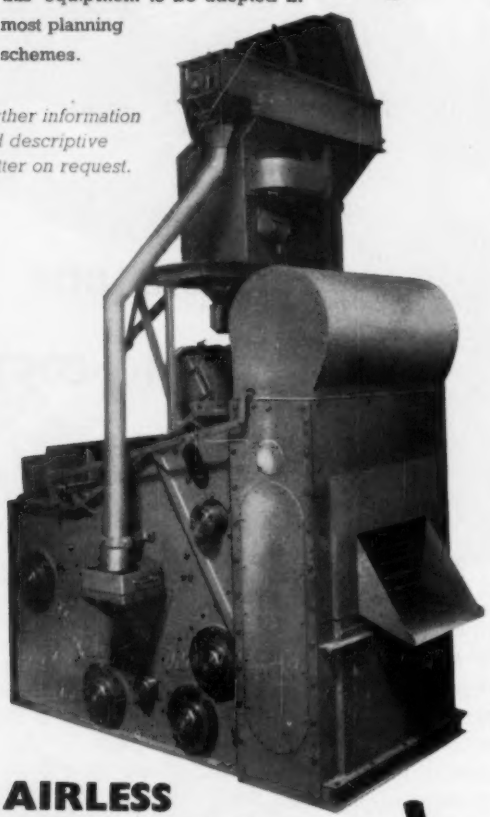

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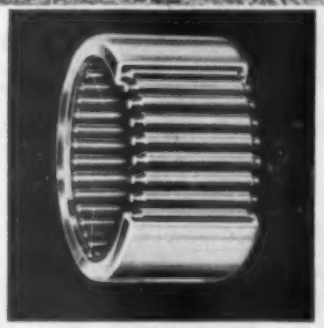

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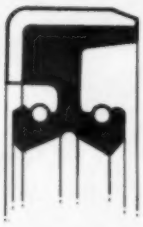

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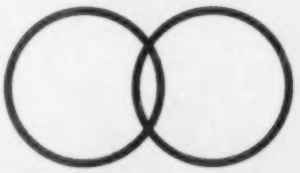

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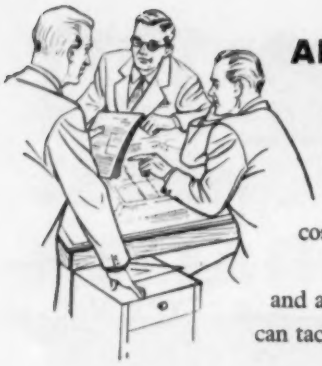

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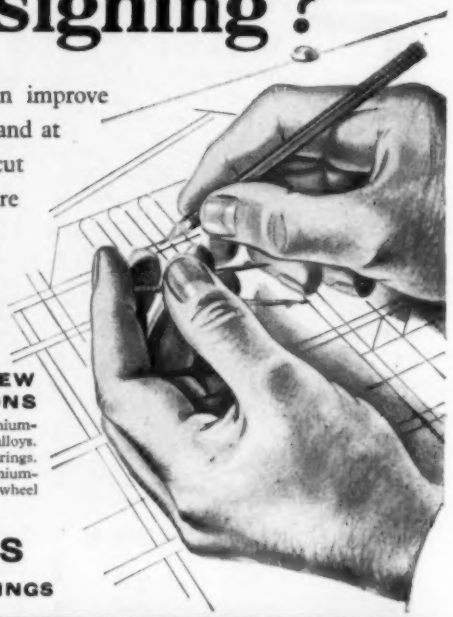

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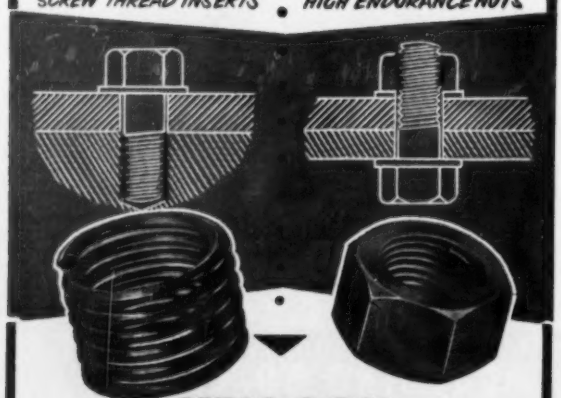

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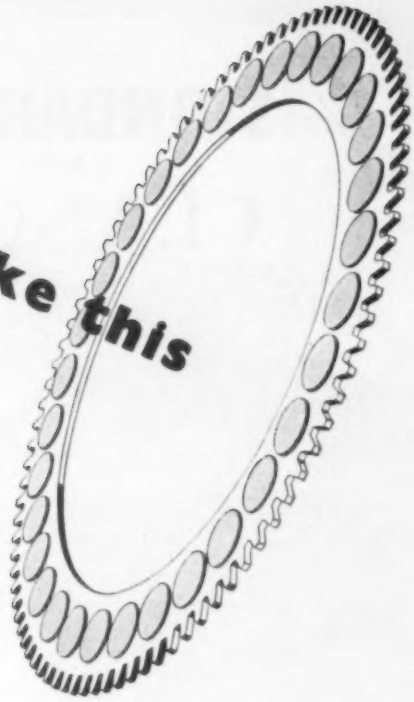

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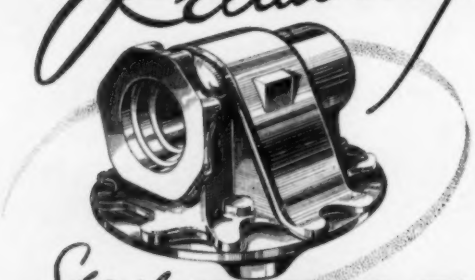

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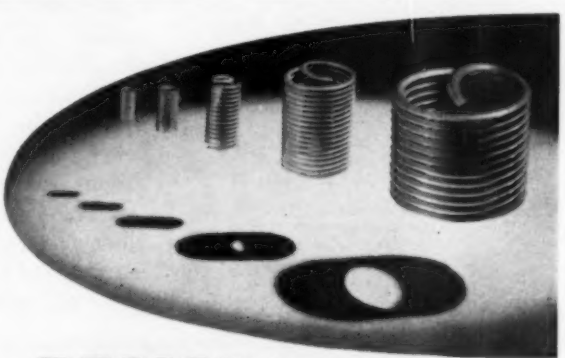

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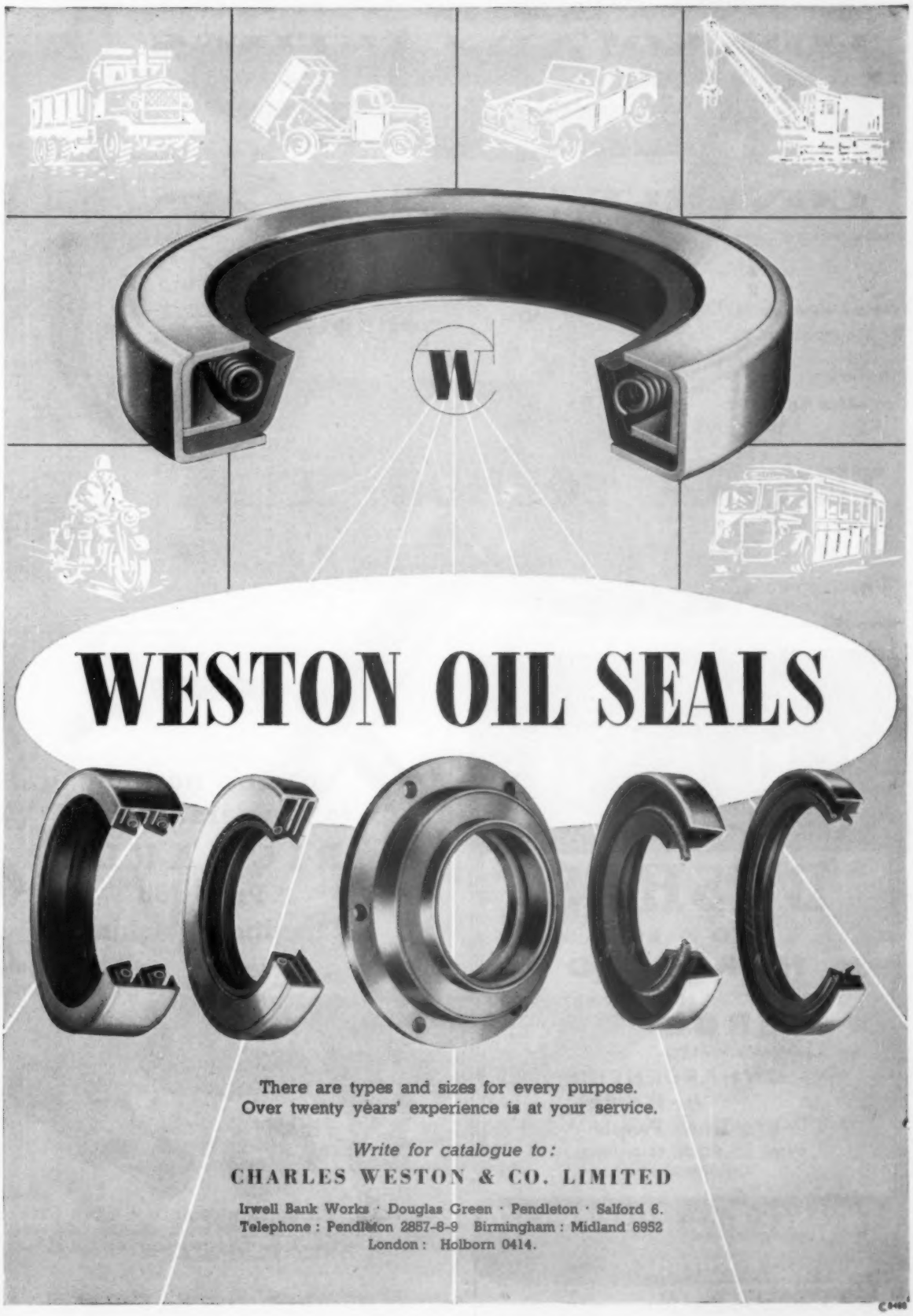
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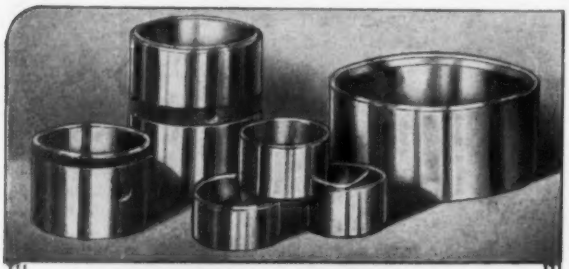

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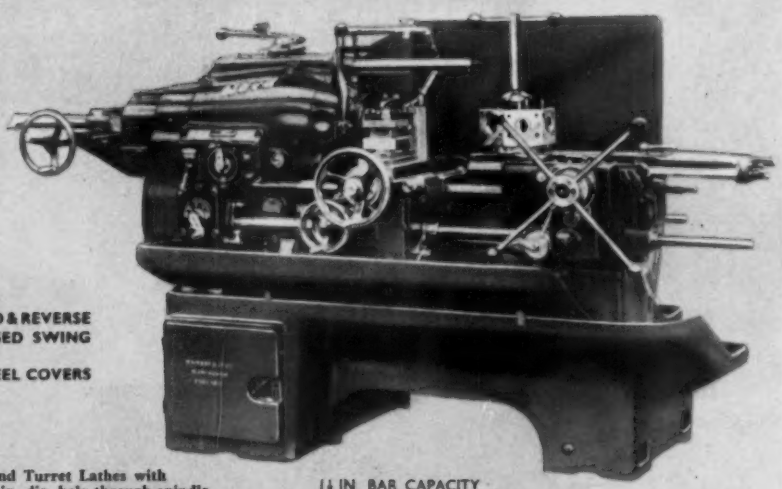

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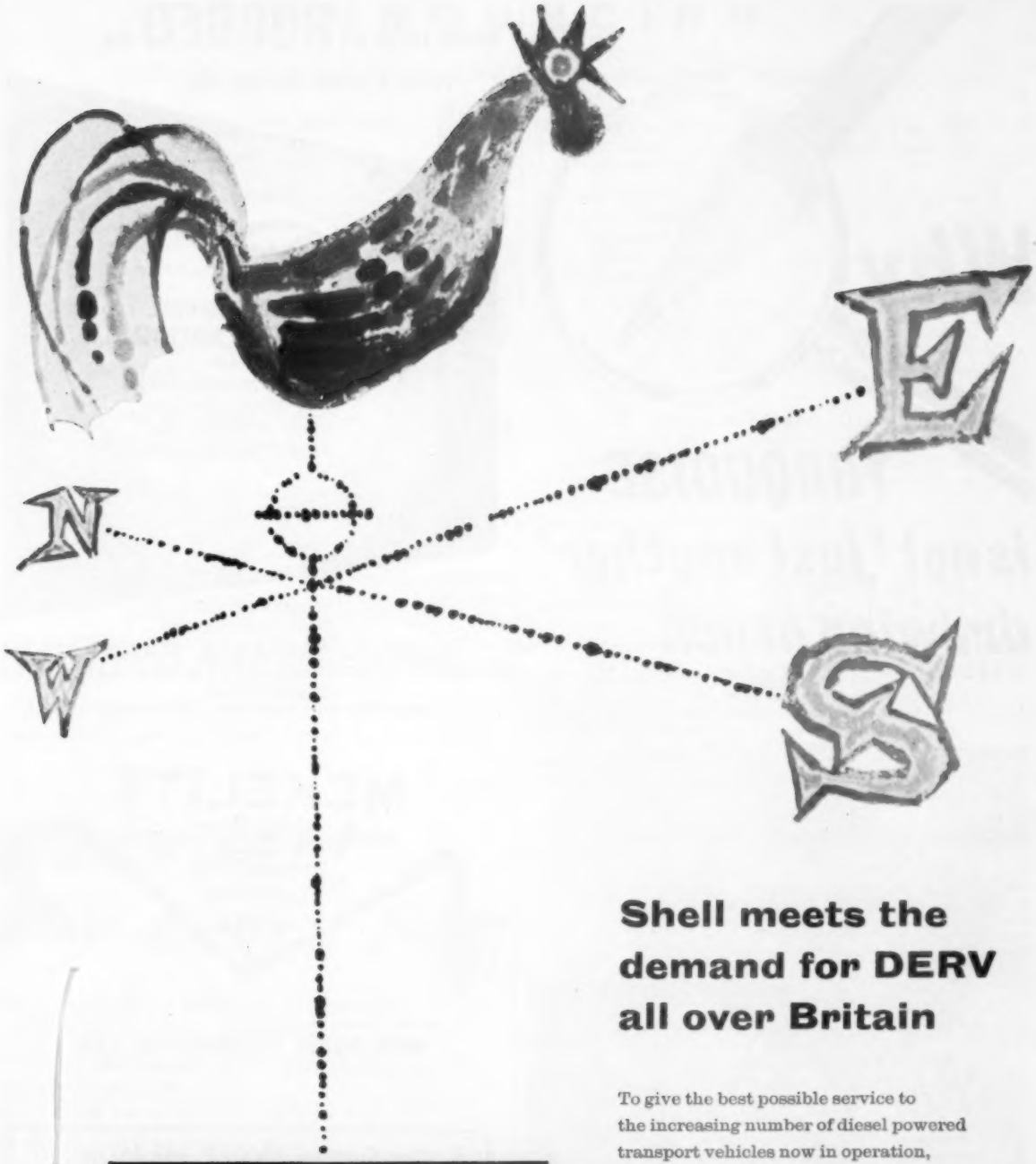

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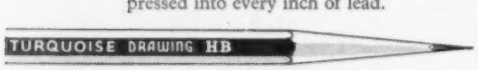

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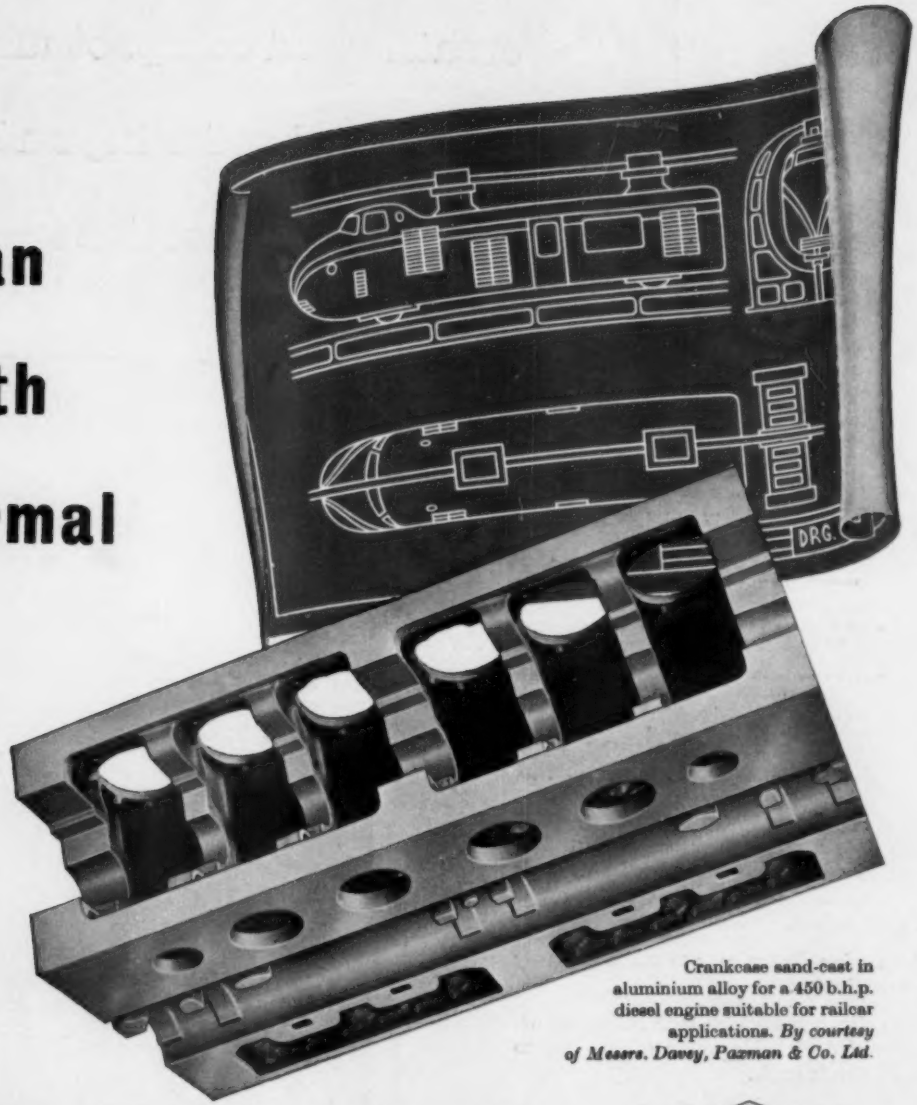

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